STUDIES ON SOME ASPECTS OF THE BIOLOGY OF A FEW INDIAN MARINE FOOD FISHES

A

Thesis

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By

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ABSTRACT*

Studies on the biology of some marine food fishes include the following investigations on four different species namely Sillago sihama (Forskal), Opisthopterus tardoore (Curier), Sardinella albella (Valenciennes) and Rastrelliger canagurta (Curier):

(a) Breeding and its related aspects such as fecundity, condition factor, ova diameter frequencies, sex ratio and so on. (b)Growth rate (c) Food and feeding habits (d) Fishery and finishing methods and (e) Morphometric studies on Opisthopterus tardoore.

Time and duration of spawning in the species noted above vary to some extent from one another. Sillago sihama and Opisthopterus tardoore have long breeding seasons lasting for about sex to seven months. In Sardinella albella the spawing season is relatively short and seems to be confined to about four months during the monsoons - June to September. The cycles of the condition factor in these species where investigations on this aspect were made seem mainly related to seasonal changes in the gonad condition. There is a secondary fall in the 'K' values of larger individuals which may indicate the onset of maturity. The minimum size at first maturity was also determined by following

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five maturity stages in various months. Size frequency distribution of the unspawned eggs in maturing ovaries of *Sillago sihama*, *Opisthopterus tardoore* and *Sardinella albella* revealed that there is no spawning periodicity in these species. Each individual seems to spawn only once a year.

Growth rate in most of the species was studied on the basis of length frequency distribution. In *Sillago sihama* age reading has also been made by the otolith. All species seem to grow rapidly during the first two years of their lives. In subsequent years, however, the growth slows down progressively.

Each species has a particular type of food preference. In *Sillago sihama*, there is a reduced food intake during the spawning months which is followed by intensive feeding after the spawning.

In *Opisthopterus tardoore*, morphometric studies have indicated that the population of this species is composed of more than one stock and the fishery of this species around karwar is supported by at least three different stocks.

Fishing methods for each species vary from place to place. Generally indigenous gears are employed for the capture of these fishes. There is no Government machanised fishing in those areas from where the material for the present study was obtained.

The importance of the above mentioned work in this country has already been emphasized in the earlier part of the thesis. Any work connected with the biology of fishes is vital to an understanding of fishery management and exploitation. It is unfortunate that no adequate information exists on the natural history of the common food fishes of India.

In the light of the importance of the work and the paucity of literature on the subject, practically all the observations presented in this thesis can be claimed to be original. In making these observations, the author has utilized practically all the sources (references) available on fishery biology of not only the species under investigation but also the classical literature on other species which was found important and helpful during the course of the present work.

The author greatly hopes that the work presented here will enhance the knowledge on the biology of the four species under investigation. Needless to say that similar work on other important species of India whether marine, estuarine or fresh water is clearly needed.

STUDIES ON SOME ASPECTS OF THE BIOLOGY OF A FEW INDIAN MARINE FOOD FISHES

CONTENTS

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I also thank Dr.G.Seshappa, Shri. M.S.Prabhu, Dr.V.Balakrishnan and Shri.P.Vedavyasa Rao my colleagues, for their valuable advice and encouragement given in the preparation of the thesis. Thanks are also due to Professor N.U.Prabhu, Sarvashri. U.N.Bhat and U.D.Naik of the Department of Statistics, Karnatak University, Dharwar, for assistance in the technique of analysis of covariance.

INTRODUCTION

India with its vast coastline amounting to nearly 2900 miles and its continental shelf of about 1,00,000 square miles in area, undoubtedly has vast marine fishery resources. The experimental fishing operations conducted by the Indian and Japanese trawlers have already shown that coastal waters of this country support fisheries of a considerable magnitude. However, our knowledge of the commercially important species is very meagre. That, a detailed study on the biology of marine food fishes is an essential pre-requisite in the management and exploitation of the fishery resources needs no emphasis. As Panikkar (1952) has rightly pointed out, "It is futile to attempt fishery management without adequate knowledge of biology of the fishes concerned". So, it is in the fitness of things that the attention of the present day fishery scientists has been rightly focussed on the investigations relating to various aspects of life history, like, feeding habits, migration, age, rate of growth, size at first maturity, spawning grounds and time and duration of spawning etc. Although much valuable information on these lines has been obtained in other countries, we have in India only made a beginning. Contributions by Pradhan (1956), Sekharan (1958), Radhakrishnan (1958) on Indian mackerel; Devanesan (1942), Chidambaram (1950), Nair (1949, 1953, 1958 and 1959) on oil sardine;

Bapat (1959) on bombay-duck; Prabhu (1955) on ribbon fish; Seshappa and Bhimachar (1954,1955) on sole fish; Radhakrishnan (1954,1957) on Indian whiting; Arora (1951) on silver bellies and Krishnamoorthy (1958), Vijayaraghavan (1955) on seer fish are worth mentioning.

Little study on the fish, Sillago sihama (Forskal) belonging to the family Sillaginidae, has been made earlier. Except for a short account of its food and feeding habits by Chacko (1949), notes on the larval and post-larval stages by Gopinath (1942, 1946), general notes by Devanesan and Chidambaram (1948) and observations on the eggs and larvae by Chacko (1950), there appears to be no other work. Cleland (1947) has given an account on the economic biology of the Sand whiting, Sillago ciliata the best known species in Australian waters. The post-larval stages of this species were described by Munro (1945) and eggs and early larvae by Tosh (1903).

A detailed study of the biology of Sillago sihama (Forskal) was undertaken in September 1953. The samples were obtained around Mandapam and Rameshwaram Island. Details of the study have been given in Part I.

Similarly little is known about the fish belonging to the genus Opisthopterus (Clupeidae), excepting the post-larval stages of Opisthopterus tardoore (Cuvier) which have been described by John (1951). In view of this, a comprehensive study of various aspects of the biology of this species was undertaken. These are given in Part II. Investigations on the biology of this fish were carried out mostly at Karwar from 1955 to 1960.

Part III deals with some observations on the reproduction of the short bodied sardine, Sardinella albella (Valenciennes). It includes studies on fecundity, maturation of gonads and spawning. The fishes belonging to this group have been studied by Delsman (1926), John (1939), Bapat and Bal (1950), Vijayaraghavan (1953), Sekharan (1955), Chacko (1956) and Chacko and Mathew (1956).

Part IV deals with observations on the mackerel fishery, Rastrelliger canagurta (Cuvier) at Karwar for the "seasons" 1954-55 and 1955-56.

In Opisthopterus tardoore for a proper understanding of its fishery, it was considered essential to investigate whether the population of this species is supported by one or more stocks. If, for instance, the entire fishery of a species is supported by a self perpetuating single stock, then intensive exploitation alone at one place, may lead to disastrous effect upon the overall catches. In such circumstances, the fishery statistics have to be carefully watched. If it shows signs of over exploitation, it becomes necessary to regulate the fishing gear and also the fishing effort. On the other hand, if the fishery is supported by more than one independent stock, over exploitation at one locality may not affect the fishery of the entire coastline, as the chances of its natural replenishment from other stocks will be bright. Many important fisheries of the world are either based on one or more than one stocks. In the Pacific pilchard, the entire population constitutes only one stock. On the contrary in Pacific halibut and Salmon, it is composed of more than one. The investigations carried out on Opisthopterus tardoore by a study on morphometry were therefore primarily aimed at studying the homogeneity or otherwise of the fish populations along the Kanara coast. Methods of analysis of the data on the basis of regression and analysis of covariance were those used by previous workers. (Godsil 1948, Roedal 1952, Schaefer and Walford 1959, Pillay 1959 and Bapat 1959).

In any biological investigations of a fish, informations on the maturity, spawning habits, the spawning periodicity, the minimum size at maturity etc. have immense value in the management of its fishery. Clark (1934) first made an attempt to study the maturity of the California sardine, Sardina caerulea by the ova diameter measurements. Hickling and Rutenberg (1936) and De Jong (1939) determined the spawning habits of some teleostean fishes by adopting the same technique. In recent years, this method has been frequently used in determining the spawning periodicities of Indian fishes. (Prabhu 1956, Dharmamba 1959). Attempts were made on similar lines to obtain information on Sillago sihama, Opisthopterus tardoore and Sardinella albella.

Methods of determining the age of the fish have been the centre of attention by fishery biologists since the earliest stages of fishery research and today they rank amongst the best known and the most important of all fishery research tools. In India, Petersen's method has been successfully used in age and growth studies in a few commercially important fishes, such as the oil sardine, Sardinella longiceps (Chidambaram 1950), the Malabar sole, Cynoglossus semifasciatus (Seshappa and Bhimachar 1954) the choodai, Sardinella albella and Sardinella gibbosa (Sekharan 1955), the silver bellies, Leiognathus splendens (Arora 1951) and the ribbon fish, Trichiurus haumela (Prabhu 1955). The age and growth of Sillago sihama and Opisthopterus tardoore based on Petersen's method have been dealt with in respective parts.

While in the temperate countries, scales, otoliths and other bony structures have proved useful methods for age determination, these structures have not been very helpful in the tropical climate. However, the possibility of scales and otoliths being useful as age indicators in some species of tropical waters have been demonstrated by the following investigators. Rao (1935), Hornell and Naidu (1923), Devanesan (1943), Chacko, Zobairi and Krishnamurthy (1948), Nair (1949), Balan (1959), Seshappa and Bhimachar (1950,1954, 1955), Pillay (1954), Jingaran (1957) and Seshappa (1958). The results of observations on Sillago sihama and Opisthopterus tardoore have been discussed in sections dealing with these two species.

The food and feeding habits of Sillago sihama and Opisthopterus tardoore have been investigated. Moreover, the fishing methods for the capture of these two species have ~~are~~ also been studied.

PART I

THE BIOLOGY OF INDIAN SAND WHITING, SILLAGO SIHAMA (FORSKAL)

CONTENTS

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THE BIOLOGY OF INDIAN SAND WHITING
SILLAGO SIHAMA (FORSKAL)

1. Distribution

Day (1889) mentioned the Red Sea, the seas of India to Malaya Archipelago and Australia as the area of distribution of this species. According to Weber and De Beaufort (1931) it occurs in the western part of the Indo-Pacific region, from Red Sea, east coast of Africa, Madagascar through India to coasts of India, China, Japan Philippines, Indo-Australian Archipelago, Australia to Bougainville Islands.

In India, this species appears to occur all along the coast. Devanesan and Chidambaram (1948) mentioned its occurrence in Ganjam (Ganjam District), Pukkilipeta, Bimilipatnam, Uppada (Godavari), Madras, Tranquebar and Sethubavachathram (Tanjore), Mukkur, Pamban (Ramnad) and Tuticorin on the east coast and Hosdurg (South Canara), Cannanore, Valapad, Calicut and Tannur on the west coast of the Madras Presidency.

2. Relationship of Body Measurements to total length

The relation between the dimensions of the external parts of the fish and its total length was determined from the measurements of over 300 specimens ranging from 5 to 24 cm. in length. The measurements taken are represented diagrammatically in Text-Fig.1.

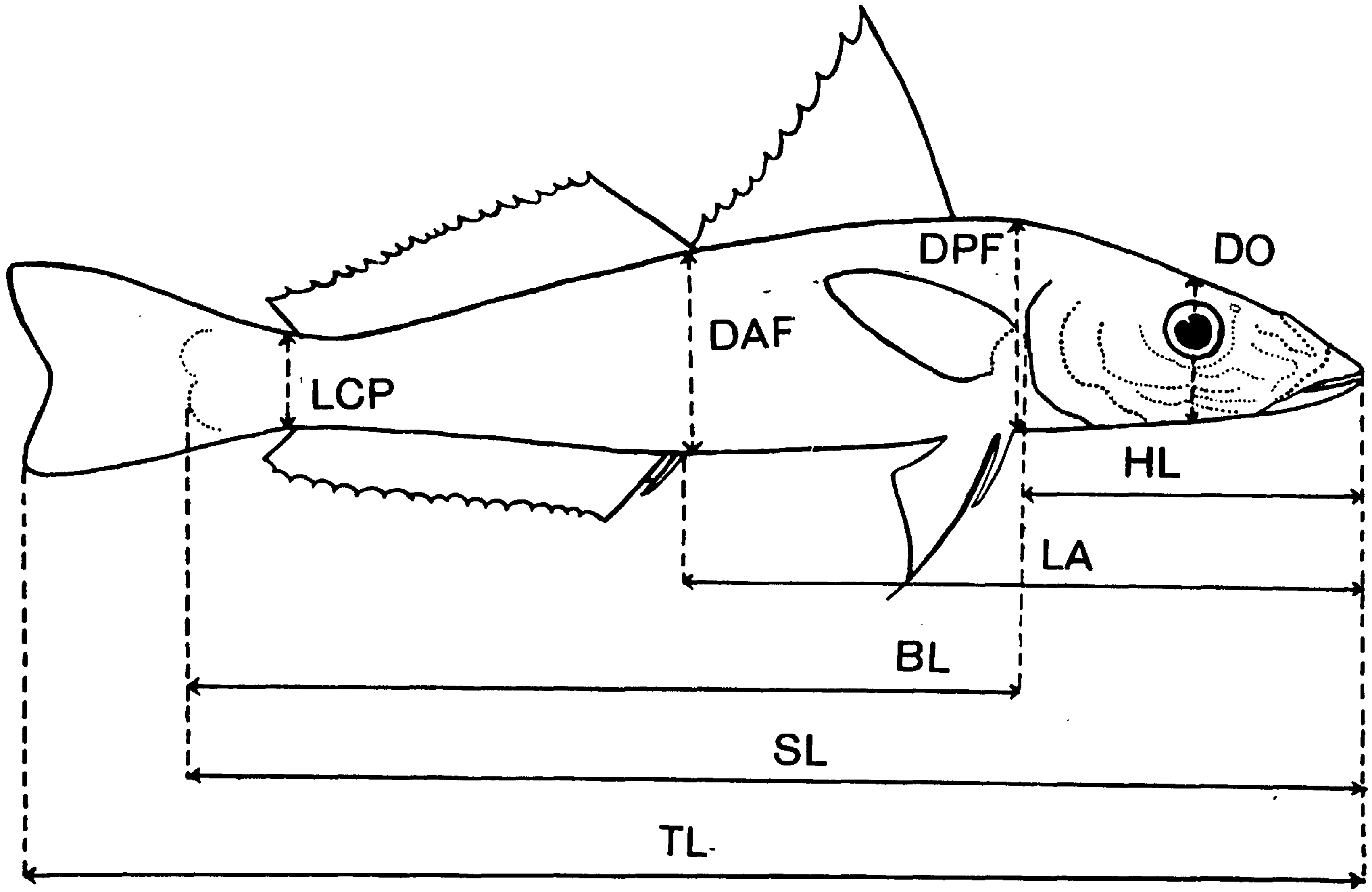
In Text-Figs. 2 and 3 the various measurements are plotted against the total length. A straight line relationship in all cases suggests that, after the 5 cm. stage, there is no allometric growth in the species. The rate of growth of the different parts of the body in relation to the increase in total length (not in relation to time) was determined by the tangent method (Crozien and Hechts, 1913). The tangent of each curve was calculated by dividing the vertical distance between two points on each curve by the horizontal distance. The data obtained by this analysis are given in Table I.

Table I.

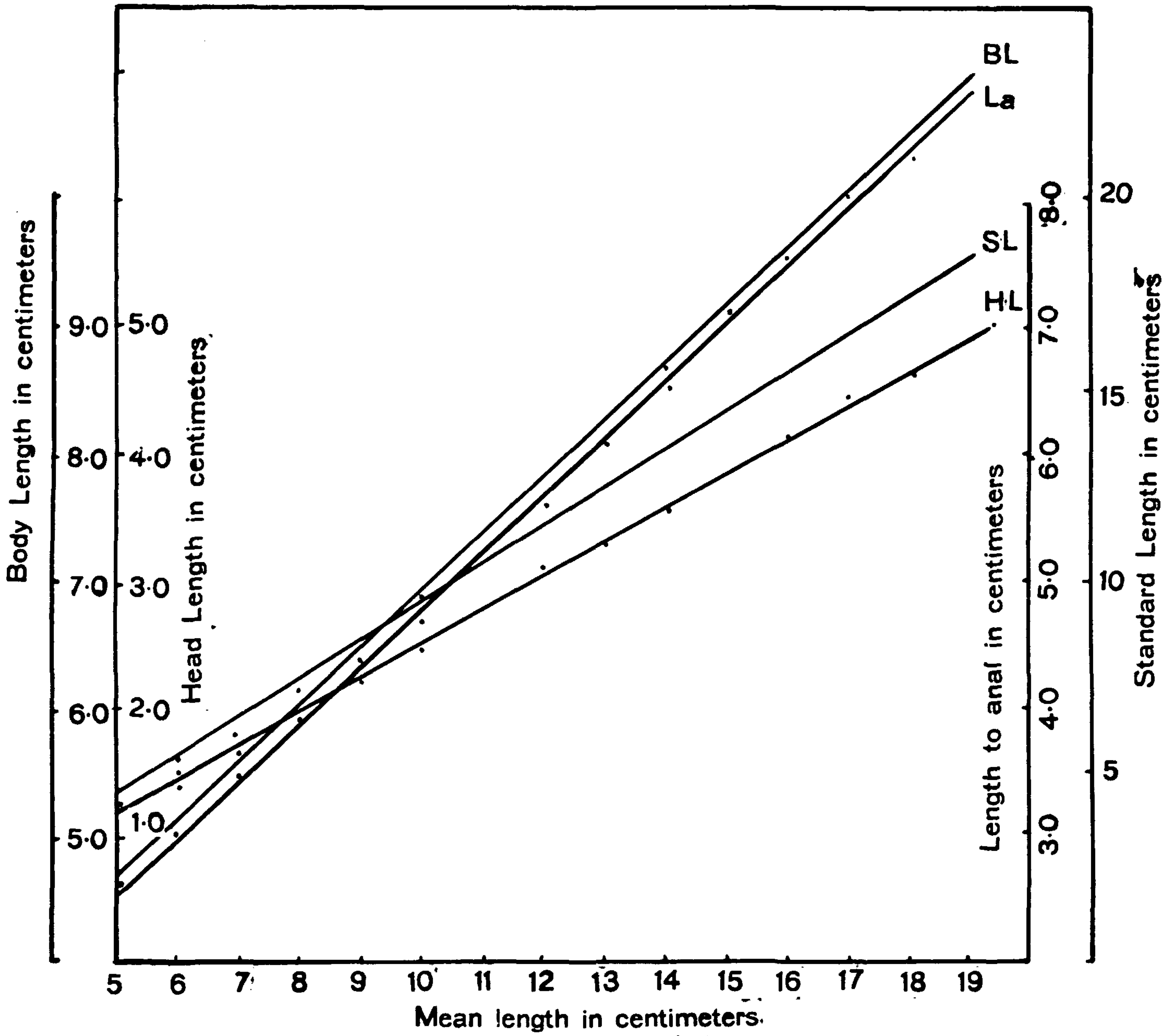
Standard length	...	0.9326
Body length	...	0.9115
Length to anal	...	0.9004
Least depth of Caudal peduncle	...	0.8381
Depth through anal fin base	...	0.8200
Depth through orbit	...	0.5856
Head length	...	0.5543
Depth through pectoral fin base	...	0.4663

Text-Figure 1. Measurements used to establish relationships of various body measurements to total length in *Sillago sihama* (Forskal)

DO : Depth through orbit
DPF : Depth through Pectoral fin base
DAF : Depth through anal fin base
LCP : Least depth of caudal peduncle
SL : Standard Length
TL : Total Length
BL : Body Length
HL : Head Length
LA : Length to anal

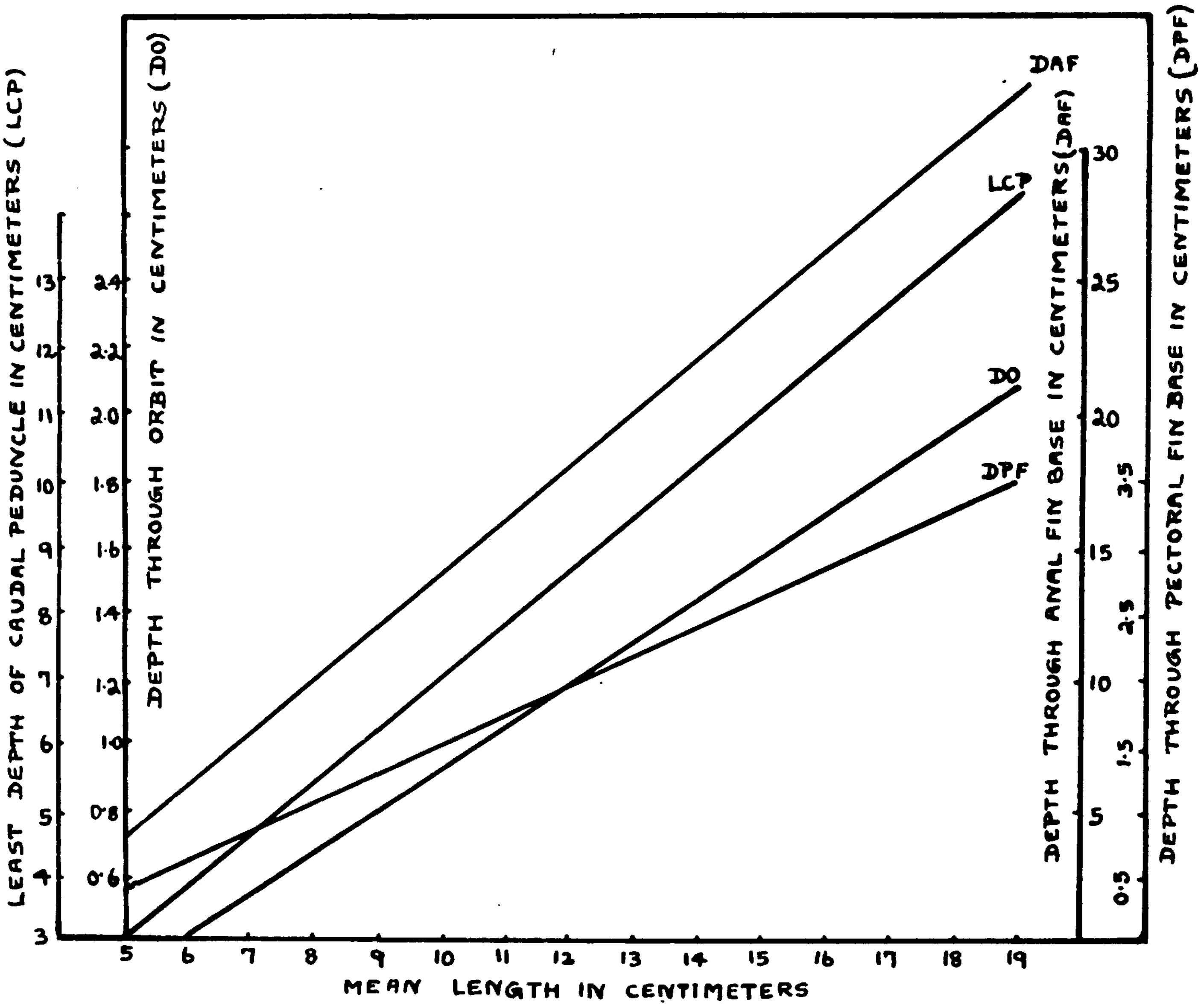

DO
DPF
DAF
LCP
HL
LA
BL
SL
TL

Text-Figure 2. The relationship of body measurements to total length in *Sillago sihama* (Forskal)



BL
La
SL
HL
Body Length in centimeters
Head Length in centimeters
Length to anal in centimeters
Standard Length in centimeters
Mean length in centimeters
5.0
6.0
7.0
8.0
9.0
1.0
2.0
3.0
4.0
5.0
3.0
4.0
5.0
6.0
7.0
8.0
5
10
15
20
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Text-Figure 3. The relationship of body measurements to total length in *Sillago sihama* (Forskal)



DAF
LCP
DO
DPF
LEAST DEPTH OF CAUDAL PEDUNCLE IN CENTIMETERS (LCP)
DEPTH THROUGH ORBIT IN CENTIMETERS (DO)
DEPTH THROUGH ANAL FIN BASE IN CENTIMETERS (DAF)
DEPTH THROUGH PECTORAL FIN BASE IN CENTIMETERS (DPF)
MEAN LENGTH IN CENTIMETERS

As can be seen from Table I, the standard length has the maximum rate of growth. Amongst the other measurements, the body length and the depth of the body through pectoral fin base have the maximum and minimum rates of growth. The body length and length to anal increase nearly at the same rate.

An analysis of the relationship between the total length and the standard length of the Indian Sand Whiting, was made to determine the degree of association of these two characters, and to establish an equation for the determination of one measurement from the other. When the standard length Y is plotted against the total length X, the points as would be expected are found to be closely clustered around the linear regression line as shown in Text-Fig.3. To express the relationship between the two variables X and Y, the equation for the regression line $Y = a + bX$ was used (a and b are the constants). The equation for the regression line was found to be $Y = 0.98X - 0.70$.

3. Weight-Length Relationship

The relationship was calculated from measurements of 520 specimens ranging from 2 cm. to 28 cm. in total length. Earlier observations revealed no marked difference in the length-weight relationship of the males and females and so calculations were made for the two sexes combined.

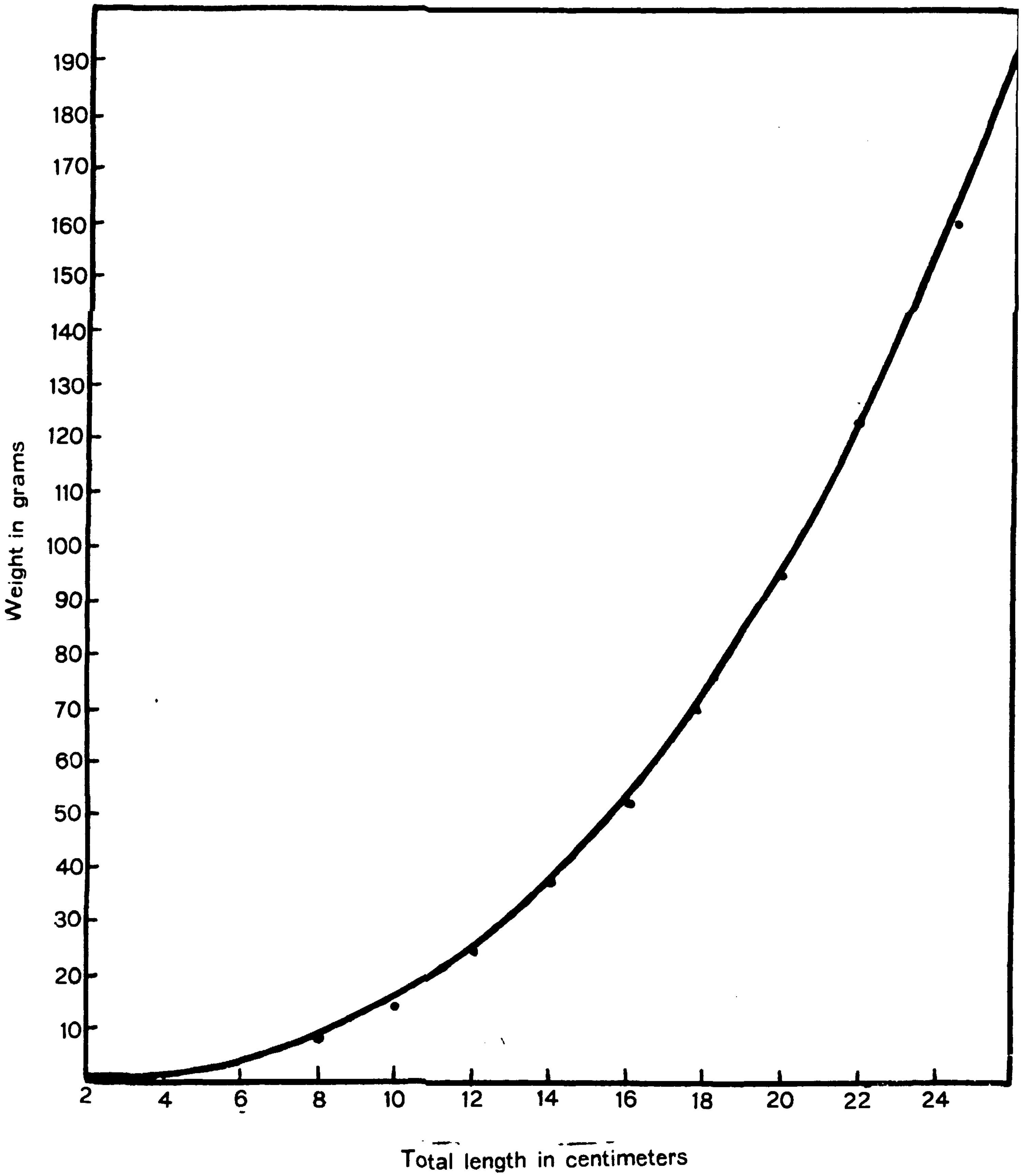
Text-Fig. 4 represents the relationship of the average weight to the length. Since the weight-length ratio is a power relationship, the logarithms of the readings were used in the calculations. The logarithmic relation of weight and length is shown in Text-Fig. 5, which clearly shows a straight line relationship.

The equation for the length-weight curve was found to be $W = 0.01504\ L^{2.8862}$ where the weight and length are in grams and centimeters respectively. Allen (1938) recorded that for all ideal fish which maintain the same shape, the value for the exponent has been found to be 3.

4. Ponderal Index or Condition Factor

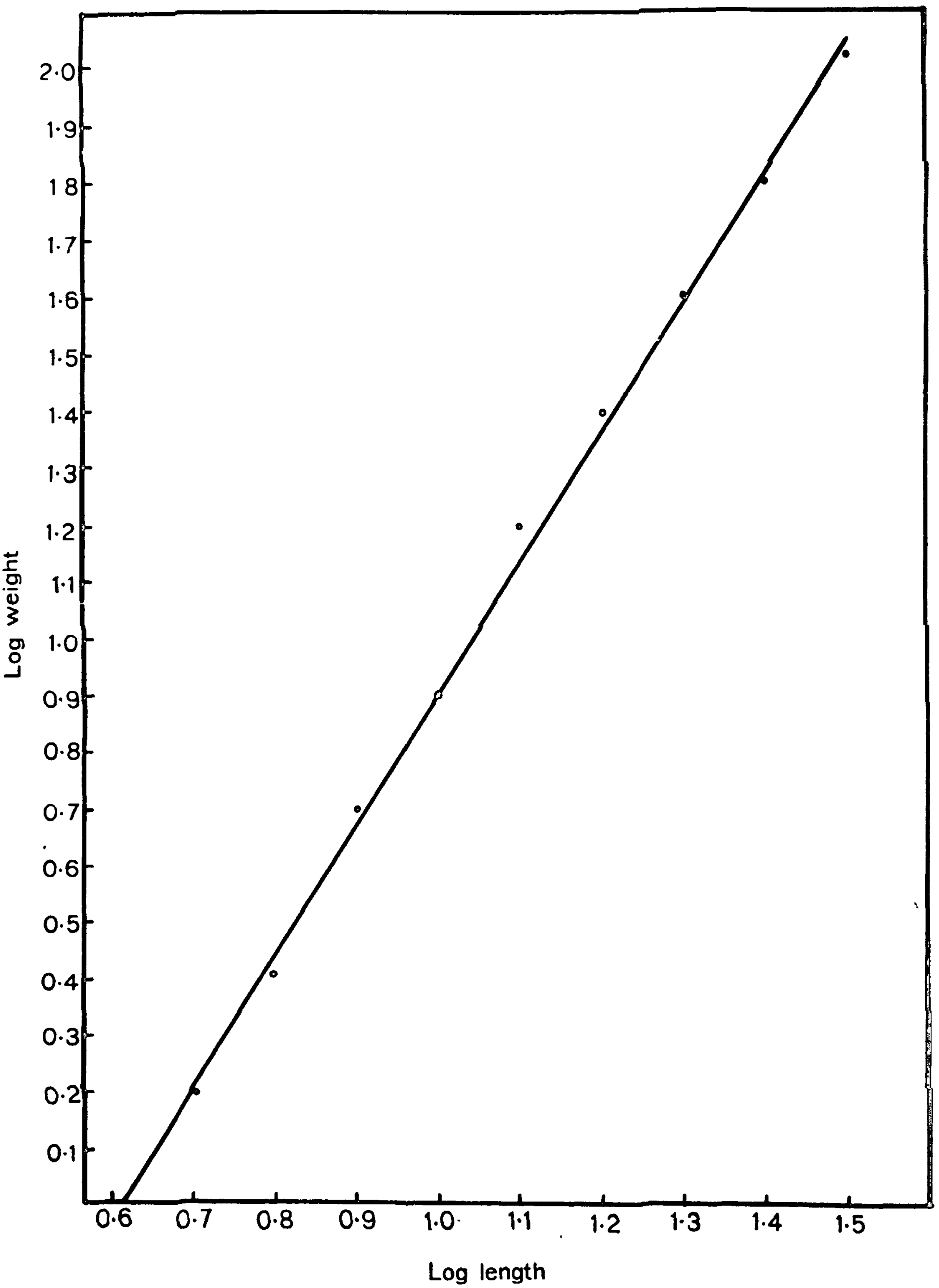
Hickling (1939), Hart (1946) and Morrow (1951) have correlated fluctuations in the ponderal index with the attainment of maturity and spawning. The weight-length data, discussed in the previous section, were analysed separately for the various size groups. Throughout the work, the weight-length coefficient 'K' was calculated by employing the formula used by Hickling (1930) and Hart (1946), viz. $K = W/L^3 \times 100$ where W is the weight of the fish in grams, L the length of the fish in centimeters and K the ponderal index. As the data available for larger fishes were very limited, fishes upto the total length of 21 cm. only were taken into account, to ensure correctness of interpretation.

Text-Figure 4. The weight-length relationship of *Sillago sihama* (Forskal)



Weight in grams
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
2
4
6
8
10
12
14
16
18
20
22
24
Total length in centimeters

Text - Figure 5. Logarithmic relation of weight and length of *sillago sihama* (Forskal)



Log weight
2·0
1·9
1·8
1·7
1·6
1·5
1·4
1·3
1·2
1·1
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·6
0·7
0·8
0·9
1·0
1·1
1·2
1·3
1·4
1·5
Log length

Hart (1946), in the report on trawling surveys on the Patagonian continental shelf, has stated that the 'K' values may give a very good idea of the broad outline of the seasonal cycle for the species. He observed that "apart from the seasonal variation in condition there is a secondary variation related to the length of the fish. With increase in age there is a lower level of condition throughout the seasonal cycle consequent upon the increased metabolic strain of spawning. The point of inflexion on a curve showing this diminution of 'K' with increasing length is thus a good approximate indication of the length at which sexual maturity is attained."

The average values for 'K' for each size-group are plotted in Text-Fig.6. If the point of inflexion of the curve is indicative of the length at first maturity, it may be said that the fish matures at an average length of 130 mm. This inference is further supported by the study of intra-ovarian eggs during the course of this investigation.

5. Food and Feeding Habits

The specimens were fixed in 5% formaldehyde and brought to the laboratory for detailed examination. The gut was then dissected and the contents removed into a petri-dish, for qualitative and quantitative analysis. Very often the food matter in the gut, especially the crustaceans, was found in an advanced state of digestion and so only the generic identification of the food components was possible. The quantitative analysis was carried out by the volumetric method in which the volume of each food item is expressed as a percentage of the volume of the total gut-contents (Hynes, 1950). The total volume of the gut-contents was determined by the displacement method in a measuring cylinder and its percentage calculated. The prevalence of each item of food in the diet during different months was calculated by the occurrence method (Hynes, 1950). In this method the number of fish in which each food item occurs is expressed as a percentage of the total number of the fish examined.

An exploratory examination of the gut-contents showed that *Sillago sihama* is an omnivorous feeder, as stated by Chacko (1949). In order to see if there was any difference in the composition of the diet in fishes of different sizes, a detailed analysis of the gut-contents of 900 specimens of different sizes was made for a period of one year.

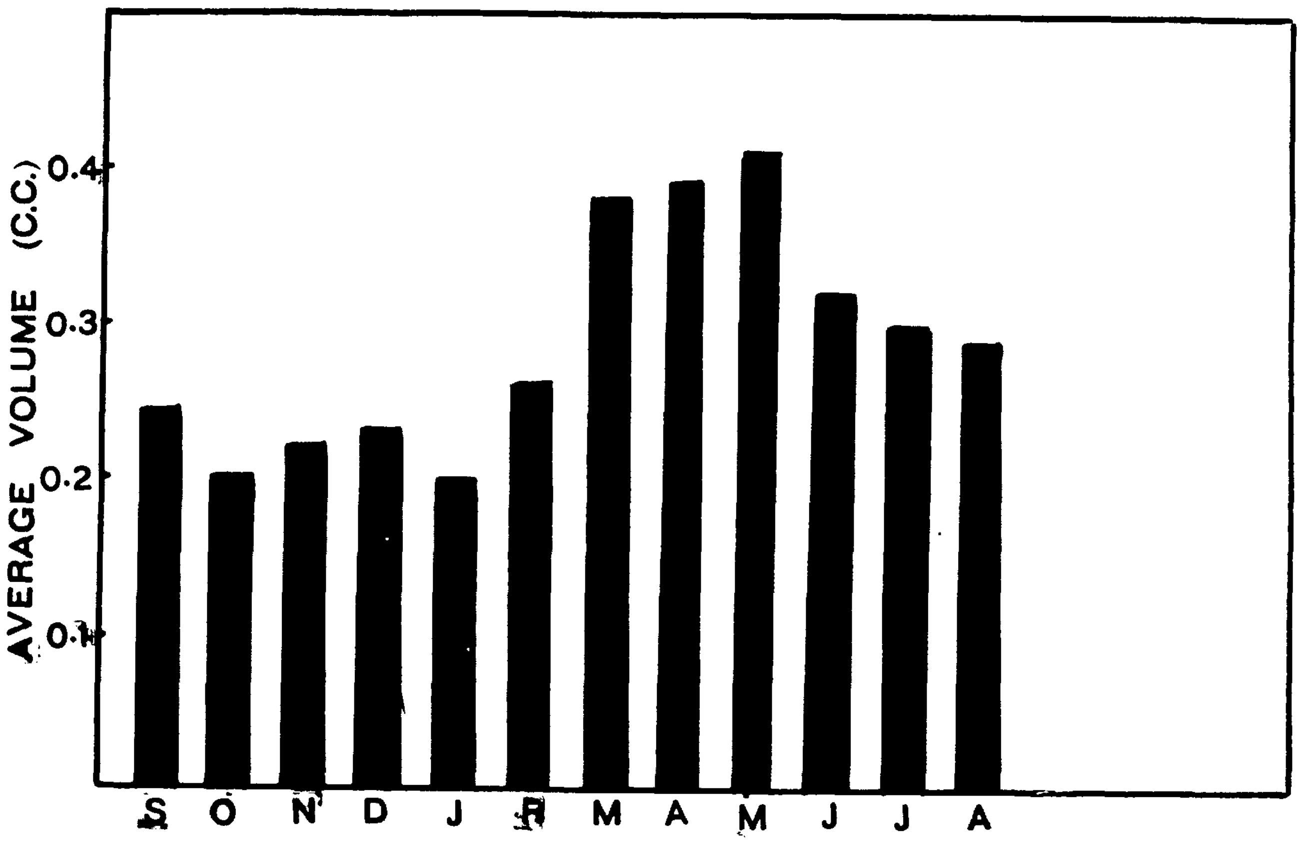
In the analysis of the stomach contents of whiting, it was found that polychaetes and crustaceans form the greater part of the food consumed. Polychaetes, crustaceans and fishes constitute the principal food material of this fish in the area investigated, besides sea weeds and bivalves in small proportion. The average volume of food per stomach for the period of investigation was 0.29 c.c.; the values for individual months are shown in Text-Fig.7.

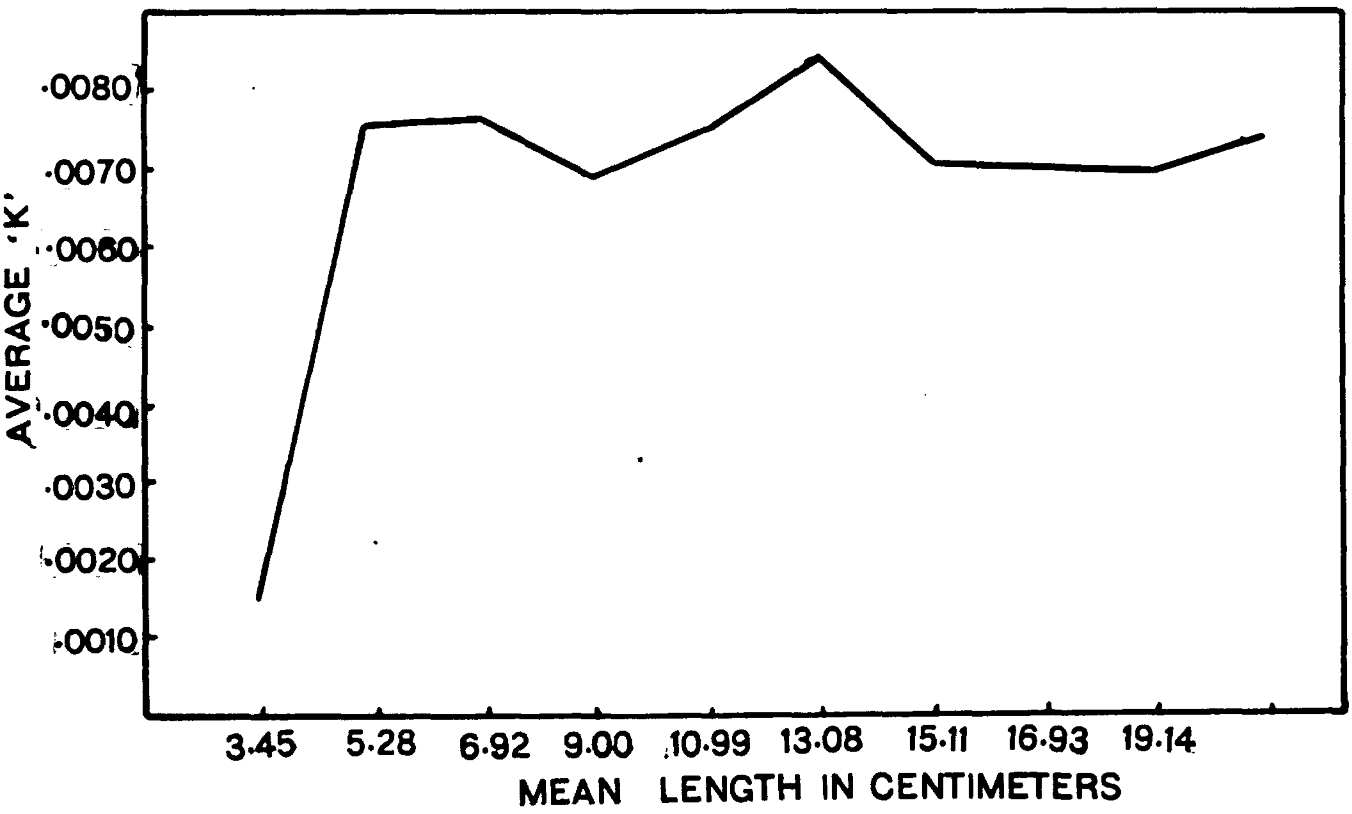
The fish were collected at about the same time of the day throughout the investigation. The volume of food in the stomach does not represent the volume consumed during feeding, because different food organisms will be digested at different rates. But, on the general assumption that the food in most stomachs has reached the same state of digestion, the results can roughly be treated as a fair guide to the feeding activity of the fish. On this basis three definite stages of feeding activity, viz., average, active and reduced, could be noticed.

It is clear from Text-Fig. 7 that the feeding becomes active from March to May, the months immediately following the spawning time, when the fish are recovering from the strain. This is followed by a period of reduced feeding activity, from June to August, which are the months just prior to spawning. During the spawning months the feeding activity is average. That the feeding activity increases soon after spawning and decreases prior to spawning is further borne out by the greater number of empty stomachs observed just prior to and during the spawning period. The percentage of empty stomachs that occurred in the respective months is shown in Text-Fig.8

Text-Figure 7. The average volume per stomach during the successive months in Sillago sihama (Forskal)

Text-Figure 6. The average 'k' - ponderal index at the different lengths of Sillago sihama (Forskal)


AVERAGE VOLUME (C.C.)
0.4
0.3
0.2
0.1
S O N D J F M A M J J A


AVERAGE 'K'
·0080
·0070
·0060
·0050
·0040
·0030
·0020
·0010
3·45 5·28 6·92 9·00 10·99 13·08 15·11 16·93 19·14
MEAN LENGTH IN CENTIMETERS

Considering the part that each of the principal food organisms plays in the food and feeding of whiting, we find that polychaetes (Nereis and Perinereis) are the commonest organisms, forming a very large proportion of the food throughout the year. They were predominant in the months following spawning. Among the crustaceans, prawns and crabs were commonly observed. Among the amphipods, Ampelisca spp. were found in the stomachs, more often in the months of June, July and August than in the other months. It is said that Ampelisca spp. are burrowers, usually lying buried under the surface layer of sand or gravel. The occurrence of these amphipods in such large numbers in the stomachs of whiting, suggests a deliberate search on the part of the fish for these forms, and it further emphasizes the bottom-feeding nature of the fish. Fishes do not constitute an important portion of the diet of the whiting, but from May to July fish fragments were found in the stomachs examined. It was not possible to identify all of them, owing to their advanced state of digestion, but Zonogobius sp. and Leiognathus sp. at least could be made out.

For the study of the food of the 0-year group, comparatively very few specimens were obtained, those too only in September 1953. The stomach contents showed amphipods of the genus Ampelisca, calanoid copepods, and also decapods and their larvae. Mysids were often found in the stomachs examined.

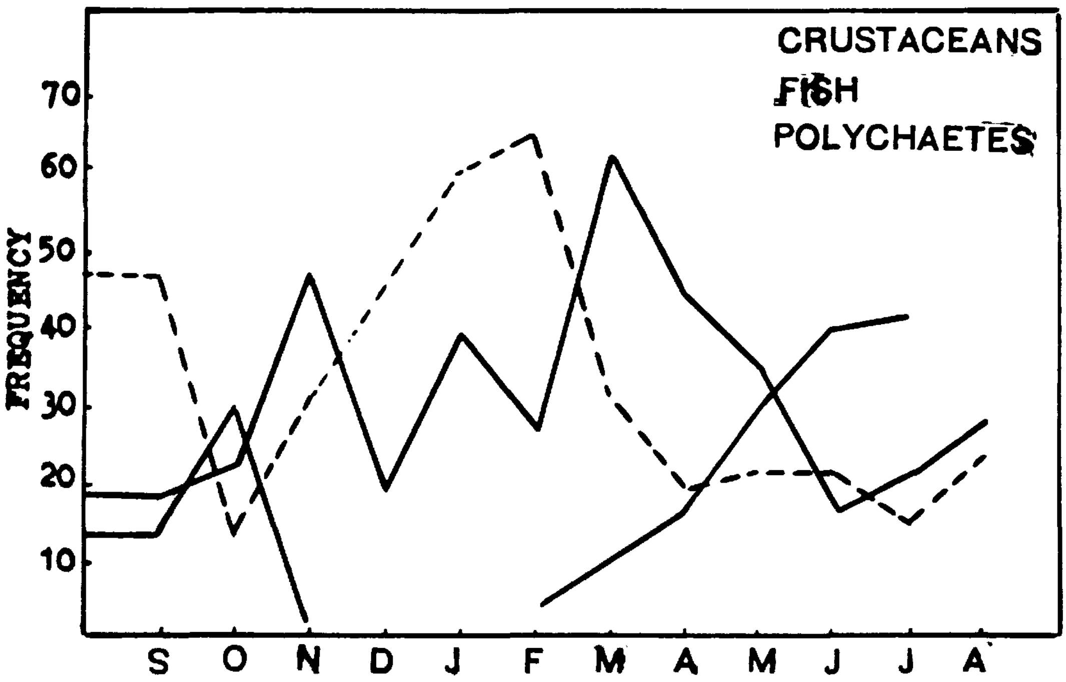
The monthly variations in the proportions of the three chief food components are given in Text-Fig. 9.

A scattering of empty broken frustules of planktonic diatoms such as *Bacteriastrum*, *Nitzschia* and *Coscinodiscus* was seen with a few Peridiniae in a few specimens during the course of the present investigation. Probably these might have been taken in quite accidentally. The fish swallows sand along with the food taken, as their intestines were always found to be filled with sand particles. To get polychaetes, the fishes probably have to dig into the sand with their snout. Devanesan and Chacko (1942) observed 12 specimens of *Balanoglossus* in a sample of 125 fishes examined around Krusadai Island. Varadarajan, as quoted by Devanesan and Chacko (1942), also has referred to the occurrence of *Balanoglossus* in the stomachs of *Sillago sihama.* During the detailed analysis of the gut contents of fish of different sizes for a period of one year, the author did not observe a single specimen of *Balanoglossus* even in the stomachs of fishes collected from near Krusadai Island.

The various food-components of *Sillago sihama* occurring in the Gulf of Mannar and Palk Bay are given in Table II.

Text-Figure 9. Frequency of occurrence of the three groups of organisms in Sillago sihama stomachs during each month expressed as percentage of the total number of stomachs examined.

Text-Figure 8. The percentage of empty stomachs that occurred in the respective months in Sillago sihama (Forskal)


CRUSTACEANS
FISH
POLYCHAETES
FREQUENCY
70
60
50
40
30
20
10
S O N D J F M A M J J A


FREQUENCY OF EMPTY STOMACHS
19
18
17
16
15
14
13
12
11
10
S O N D J F M A M J J A

Table II

Fishes	Polychaetes	Crustaceans	Miscellaneous
Zonogobius sp., _Leiognathus_ sp., Packets of Cycloid scales.	Nereis, _Marphysa_; _Perinereis_; _Armandia_; and indistinguishable moults of others.	_Penaeus indicus_; _Gonodactylus_; _Ocypoda_; _Alpheus_; Shrimps; Mysids, Amphipod of the genus _Ampelisca_; Calanoid copepods; Decapods and their larvae; Appendages of crustaceans were often found.	Sea weeds - (_Sargassum_, _Enhalus_) Remains of bivalve shells; Gastropod shells occurred rarely.

6. Maturation and Spawning

(i) Maturation: The study of the intra-ovarian eggs in the ripe ovaries of penultimate stages of maturity is the basis of the present investigation which was initiated with a view to determining the duration of spawning period. The procedure, similar to that adopted by Clark (1925), Arora (1951) and Prabhu (1955, 1956) was employed with a view to avoiding any deliberate selection or bias in taking the measurements. Prabhu (1956) considered that the measurements of at least 1,000 eggs were necessary to mitigate the probable error in the representation of various groups of eggs in different stages of maturity. So the diameters of nearly 1,000 ova were taken irrespective of which axis lay parallel to the micrometer. This procedure ensures the random nature of the readings and represents, with fair accuracy, the numerical ratio of eggs in different size groups.

Text Figure 10 represents the size frequency distribution of ova in six nearly ripe specimens obtained during the spawning period. The total range in size of the intra-ovarian eggs was 0.0501 to 0.517 mm. From the modes of the curve in Fig. 10 two distinct stages can be recognized in the maturation of the ova. Mode 'A' consists of eggs which are purely immature ones. Another mode 'B' represents mainly the mature and ripe eggs. Moreover, the eggs under the mode

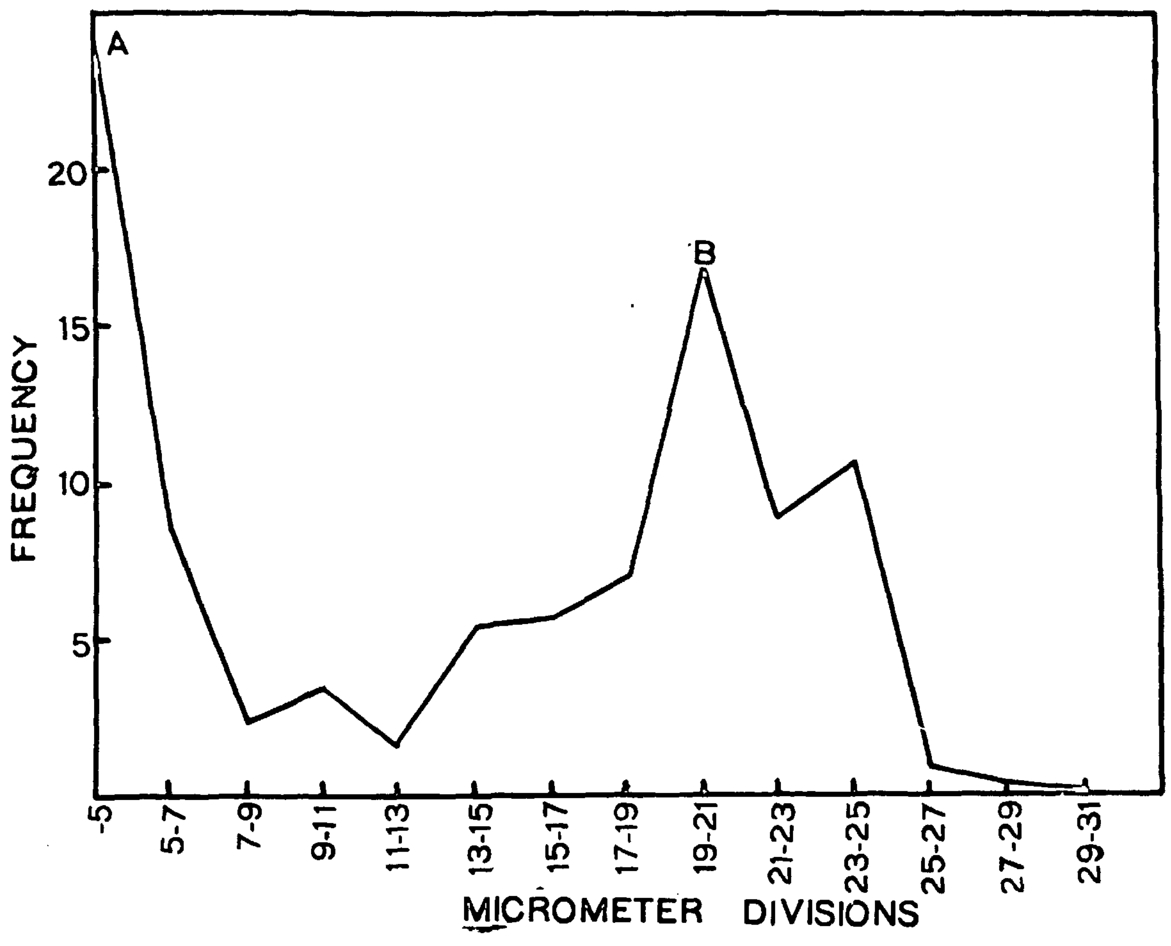
Text-Figure 10. Frequency of ova in different size groups from ovaries of five different individuals of *Sillago sihama* (Forskal)

'B' seem to be sharply differentiated from the immature ones. The numerical ratio between the eggs in fully ripe condition and the next group of eggs in mature condition indicates that the former are comparatively less in number. It is quite possible that, by the time the fully mature ova are shed, the latter batch of eggs would have attained full maturity, to be spawned subsequently. From these, it could be concluded that this species spawns only once in a year. The smallest female in roe examined during this investigation was 130-140 mm. in total length. This observation corroborates the inference drawn from the fluctuations in the ponderal index that the average size of the fish at first maturity is 130 mm.

The ovaries were yellowish in colour, containing ova of all the four stages of maturity. Various workers have adopted different types of classification for the intra-ovarian eggs, but the following convenient method was followed for the present study.

<u>Stage I</u> - Immature ova : Transparent ones which could be distinctly recognized as possessing a prominent central nucleus and a protoplasmic layer devoid of any yolk accumulations. The size varies from 0.0334 - 0.167 mm.

<u>Stage II</u> - Maturing ova : Small, opaque ova in which the yolk formation has just commenced, but which are not fully yolked. The diameters vary from 0.183-0.217 mm.


A
B
FREQUENCY
20
15
10
5
-5
5-7
7-9
9-11
11-13
13-15
15-17
17-19
19-21
21-23
23-25
25-27
27-29
29-31
MICROMETER DIVISIONS

<u>Stage III</u> - Mature ova: Opaque and yolky with distinct yolk spherules but still contained within the follicles. The size ranges from 0.233-0.400 mm.

<u>Stage IV</u> - <u>Ripe ova:</u> Fully mature, large, free, fully or partly transparent eggs which have burst from the follicles, the diameter range being 0.417-0.517 mm.

Mode 'B' in Text-Fig. 10 contains ova in stages III and IV. Since the samples examined did not contain any fish in oozing condition, it is quite probable that the fully ripe ova may be slightly larger than the size described above. Chacko (1950) observed eggs and larvae of <u>Sillago sihama</u> from the plankton around Krusadai Island. Gopinath (1946) has described the advanced past-larvae of <u>Sillago sihama</u> which begin to appear along the Travancore Coast by the end of December.

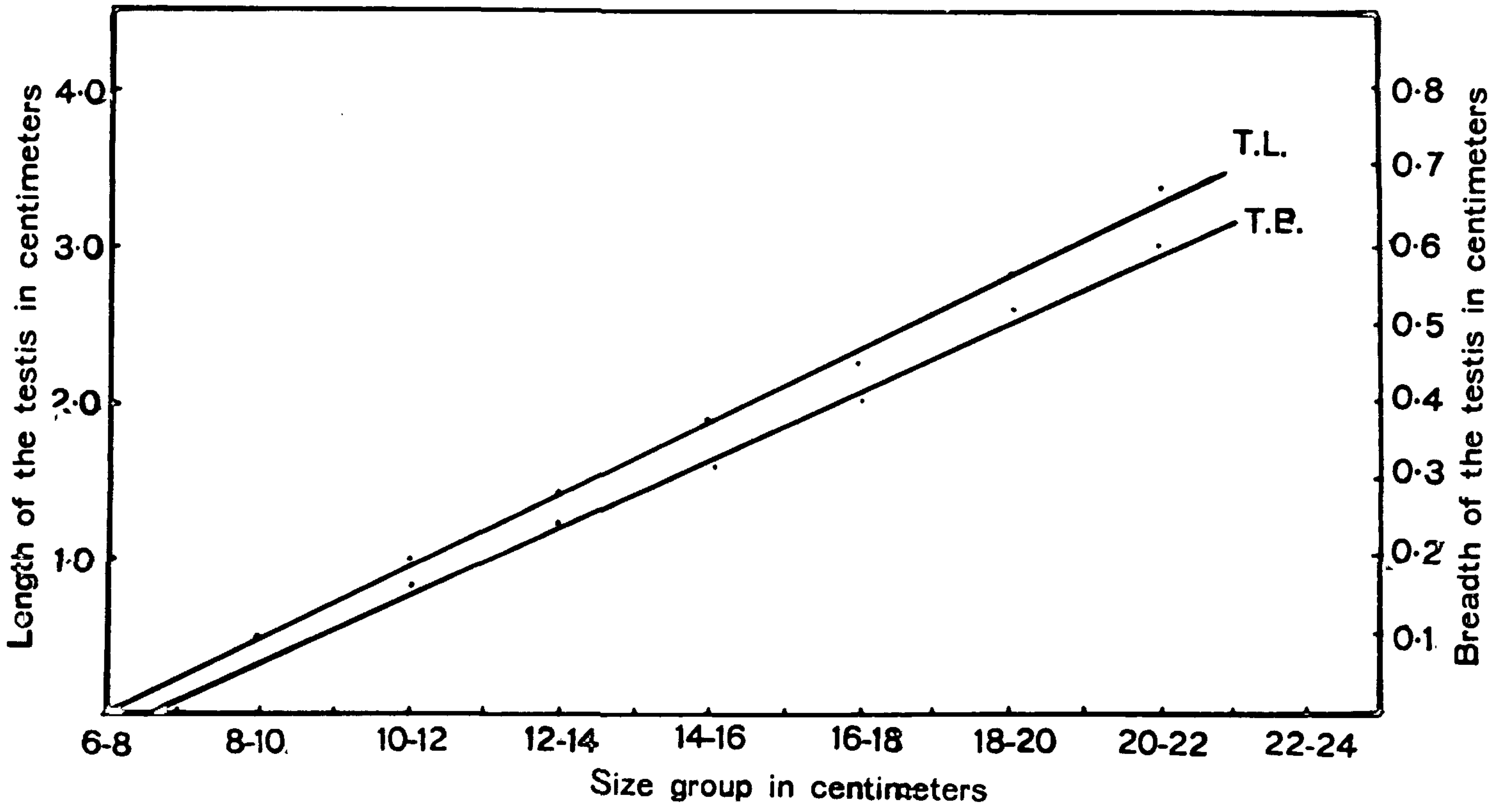
(ii) <u>Growth rate of gonads:-</u> With a view to knowing how the size of gonads in the fish is actually related to their lengths and how the gonads in male and female are related to the length of the fish even in immature forms the entire range in size of the specimens available in the usual commercial landings was conveniently divided, with a class interval of 2 cm. The average size of the ovary and testis in each size group was determined from the total of 330 observations. In calculating the theoretical values of the sizes of ovaries and testis, the midpoints of each size-group were taken into consideration. To express the relation between the two variables X and Y (X being the length of the fish in cm.; Y the length of ovary or testis in cm.) the equation for the regression line $Y = a + bX$, where a and b are the constants, was used. The equation for the regression line in the case of ovary and testis were found to be $Y = -1.5677 + 0.2533\,X$ and $Y = -1.893 + 0.2489\,X$ respectively. When these observed values for Y were plotted against their respective calculated values it was seen that the points were more or less closely located near the linear regression line. The data are plotted in Text-Figs.11 and 12. It could be inferred that for every 10 cm. increase in the length of the fish the lengths of the ovary and testis increase approximately 2.53 cm. and 2.48 cm. respectively.

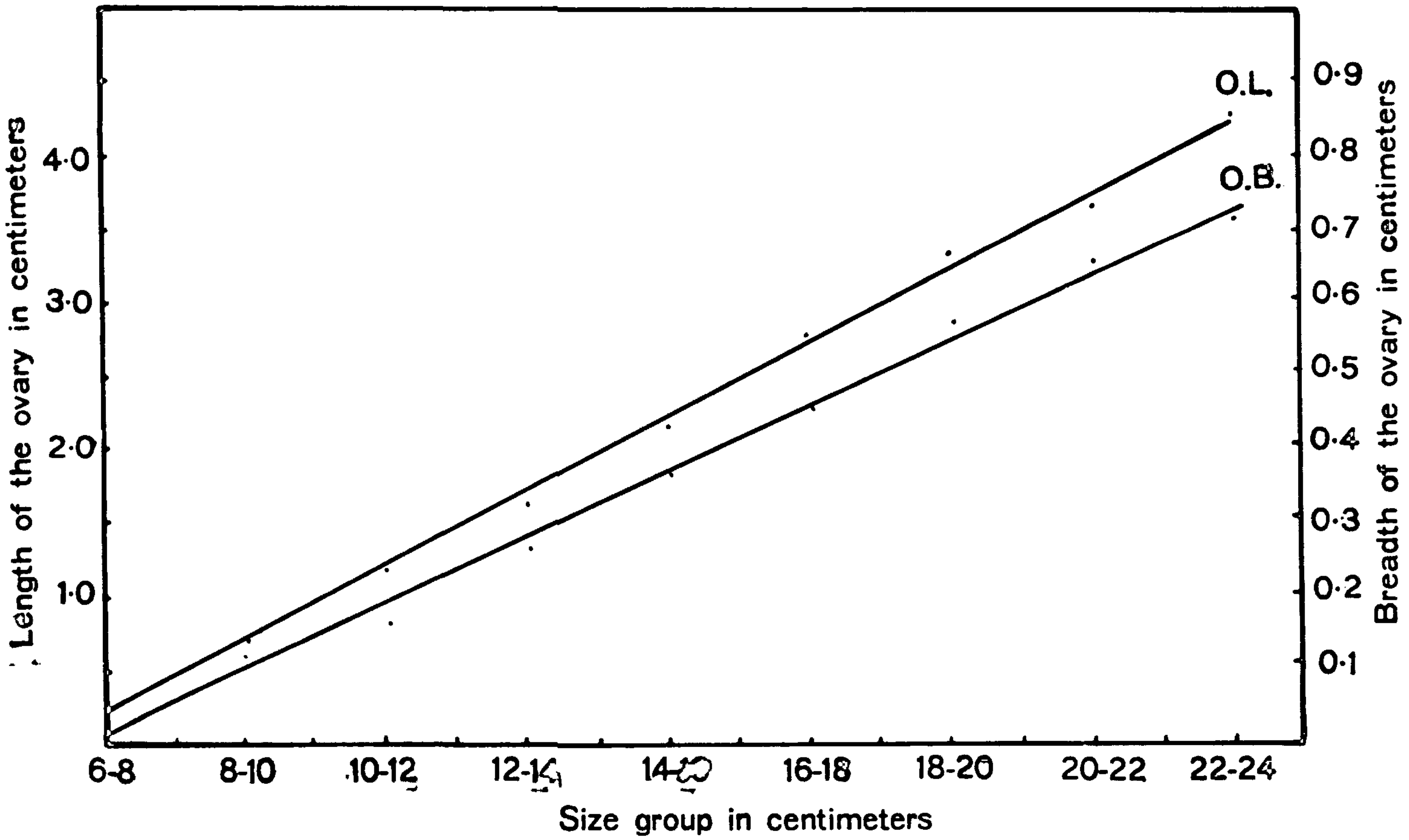
Similarly the average breadth of the ovary and testis, was calculated from the total of 330 observations. The equations for the regression line in the case of ovary and testis were found to be $Y = -0.3037 + 0.0449\,X$ and $Y = -0.3003 + 0.0424\,X$ respectively. It could be inferred that every 10 cm. increase in the length of the fish the breadths of the ovary and testis increase approximately by 0.44 cm. and 0.42 cm. respectively.

As can be seen from the above description the length and breadth were found to increase at a greater rate in the ovary than in the testis in *Sillago sihama*. It is

Text-Figure 11. Observed and calculated (-) length and breadth of testis of Sillago sihama (Forskal)

Text-Figure 12. The observed and calculated (-) length and breadth of ovary of Sillago sihama (Forskal)


Length of the testis in centimeters
Breadth of the testis in centimeters
4·0
3·0
2·0
1·0
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
T.L.
T.B.
6-8
8-10
10-12
12-14
14-16
16-18
18-20
20-22
22-24
Size group in centimeters


Length of the ovary in centimeters
Breadth of the ovary in centimeters
4·0
3·0
2·0
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
O.L.
O.B.
6-8
8-10
10-12
12-14
14-16
16-18
18-20
20-22
22-24
Size group in centimeters

quite probable that the weight of the ovary also increases at a slightly higher rate than the weight of the testis.

(iii) Spawning Season:- The small sized individuals measuring 2-4 cm. were obtained during this investigation only during the rainy season. The observation regarding the spawning season was verified by studying the size progression of ova during the different months of the year. The immature eggs occur in every adult female during all the months of the year. The largest eggs examined in September showed the nearly ripe condition. Such ova have been found in the ovary up to February. It is inferred that the spawning season of the fish extends from about August to February with a peak period in October. Specimens with actual oozing of ova have not been examined and the nearly ripe ova may take some time to become fully transparent, and ready for spawning. So the period indicated gives only an approximate picture of the spawning season.. The data of the monthly size progression of the ova is given in Table III.

(iv) Spawning ground and occurrence of larvae:- It is likely that spawning takes place in the mouths of rivers as suggested by Chaudhuri (1923). According to him, this fish is a permanent inhabitant of the Chilka lake and goes out to the sea or the mouth of the lake for breeding. During this investigation larger whitings were very scarce. The absence of eggs and larval forms of this fish in inshore

TABLE NO.III

MONTHLY SIZE PROGRESSION OF OVA IN SILLAGO SIHAMA (FORSKAL)

THE RANGE IN SIZE OF OVA FOUND IN ANY PARTICULAR MONTH IS REPRESENTED BY THE COLUMNS OF CIRCLES; THE MAJORITY OF FEMALES HAD OVA OF THE SIZES INDICATED BY THE SOLID CIRCLES.

Maturity	Diameter in micrometer divisions	S	O	N	D	J	F	M	A	M	J	J	A
Fully ripe	31-33	○	●	○			●						
	28-30	○	●	●		○						○	
	25-27	●	●	○	○	○	○			○		●	●
Mature	22-24	●	●	○	●	●		○		○	○	●	
	19-21	●	●	●	○	●	○	○	○	●	○		
	16-18	○	●			○		○	○				
Maturing	13-15		●			○		○			●	●	
	10-12			○					●	●			
Immature	7-9	○		○	○			○					
	4-6	●	●	○	●	●	○	○	●	○	○	●	○
	1-3	●	●	●	●	●	●	●	●	●	●	●	●

1 micrometer division = 0.0167 mm.

waters indicate that the spawning takes place somewhere beyond the present fishing limit. It is probable that an intensive study of the fish taken from deeper waters may throw more light on the spawning habits.

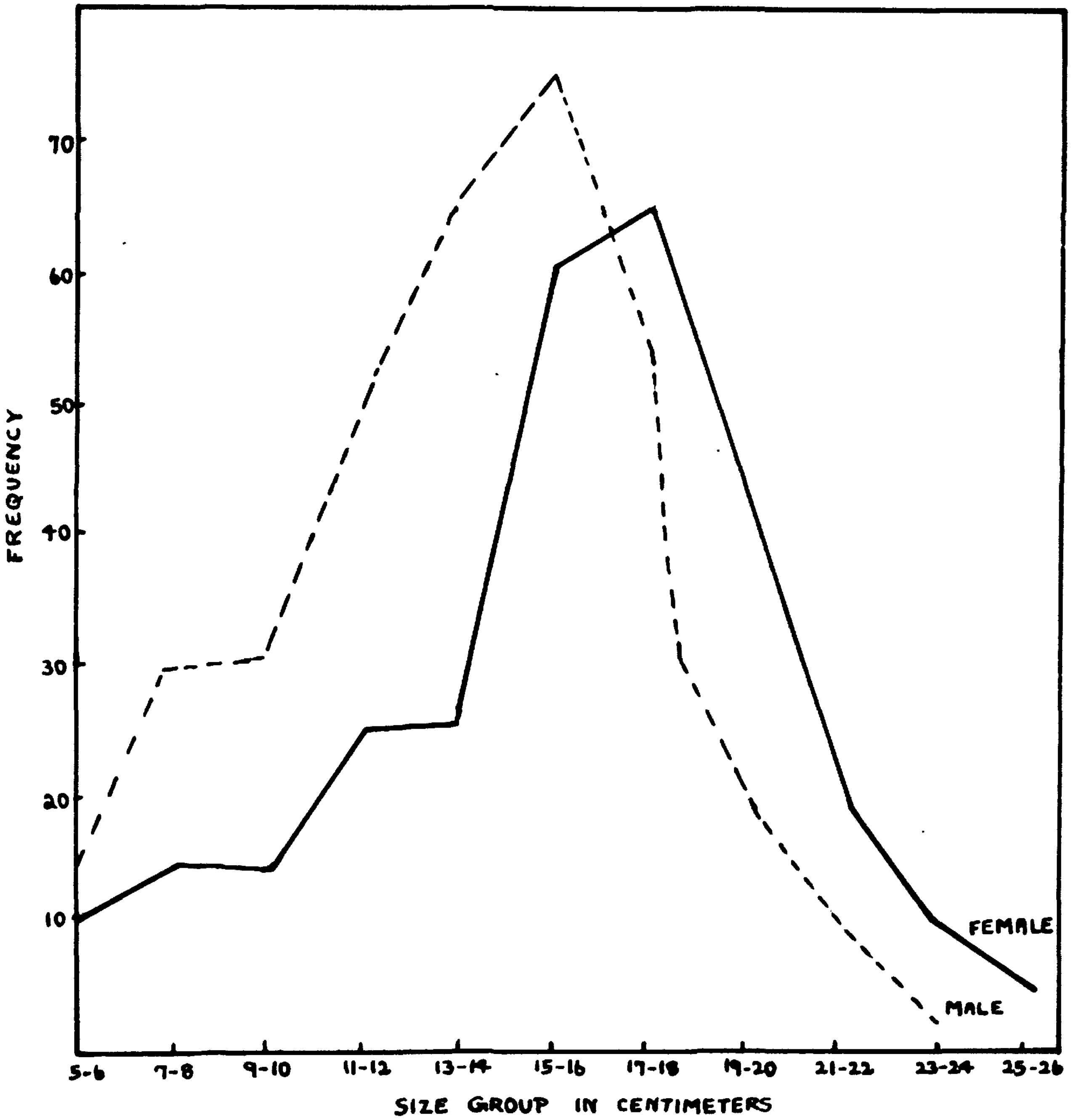
7. Sex Ratio

The sex composition, of the random samples examined in 1953 and 1954, was 55.6% males and 44.4% females. Size frequency of the males and females in 5 cm. range of total length is given in Text-Fig. 13. It was also noticed, that the males formed a higher percentage than the females in the size groups upto 17 cm.

8. Age and rate of growth

It was found, when this present study was started in September 1953, that there were distinct zones on the otolitths of Indian whiting an attempt was made to see whether these could be used in the same manner as Nair (1949) used them to age the Oil Sardine, Sardinella longiceps. At first it was assumed that the zones on the otoliths were annual and the age determined from the number of zones was compared with the estimates of growth obtained from the other method, namely, Peterson's method of tracing the length frequency modes. To test the assumption that the zones were annual, the study of the growth at the edge of the otolith, according to the season, was made.

Text-Figure 13. The length frequency polygons of Males and Females of <u>Sillago sihama</u> (Forskal)



70
60
50
40
30
20
10
FREQUENCY
FEMALE
MALE
5-6
7-8
9-10
11-12
13-14
15-16
17-18
19-20
21-22
23-24
25-26
SIZE GROUP IN CENTIMETERS

Detailed examination of the scales taken from the axillary region, just behind the pectoral fin, revealed that only some of them show the formation of clear annuli, particularly in the advanced size-groups, while in the earlier stages these annuli are not very clear. Since the occurrence of rings on the scales were of a very small percentage it was not helpful for the study of the rate of growth.

(i) <u>Age estimates from otolith studies:</u>- An attempt was made to discover if there is a relationship between the selected otolith length and the total length of the fish expressible as an equation involving one or more constants. For this part of the study, there were measurements available of all the otoliths examined. To express the relationship between the two variables X and Y (X = length of the fish in cm., Y = length of the otolith in cm.) the equation for the regression line $Y = a + bX$ was used (a and b are the constants). The equation was found to be $Y = 0.23+0.027X$. When the observed values of Y were plotted against the respective X values, it could be seen that the points were more or less closely located near the linear regression line as shown in Fig.14.

The methods employed throughout the investigation were similar to those of Nair (1949). The procedure often gives an unevenly ground surface, with liability to frequent fractures. This was minimised by carefulness in grinding. and in examination of the otolith frequently with a magnifying glass. Instead of mounting the otoliths in canada balsam, as suggested by Nair, keeping the otoliths in small air-tight specimen tubes, with a drop of xylol in it was found to give better results. The best method for the examination of an otolith is by placing it in a watch glass with xylol and orientating it until a uniform field of light struck the convex surface at right angles. All age assessments were made after such examination. The two otoliths from the same fish were always found to have identical markings. Age estimates were made in a manner similar to that adopted by Bowers (1954) in *Gadus merlangus* L., from the number of bands and zones on the otolith as follows:

1.	Otolith with no translucent band.	...	Age group	0
2.	Otolith showing centre and translucent edge	...	,,	1
3.	Otolith showing centre, translucent band and opaque edge.	...	,,	1
4.	Otolith showing centre, translucent band, opaque zone and translucent edge.	...	,,	2
5.	Otolith showing centre, two translucent bands, with opaque zone in between and opaque edge.	...	,,	2

and so on upto age 4. In short the fish was allotted to the age-group corresponding to the number of translucent bands seen on the otolith, irrespective of whether the outermost translucent band was at the edge or within an opaque edge.

The age determination from otolith readings were based on the assumption that growth rings on the otoliths are laid down annually. There is no absolute proof available that this is true (Graham, 1929) as the seasonal records of the state of the edge of the otoliths were incomplete. Age determination made by means of otolith readings showed that the fish in all age groups upto 4 were present in the area investigated; age groups 1 to 3 were well represented, but the older fishes were scarce. A migration might account for the scarcity of 3-year old fish in the sample examined. Lack of evidence on this point may be owing to the fact that this investigation was limited to depths of 8-10 fathoms.

The range in length and the mean length in each age group are shown in Table IV. The mean length at age group 4 may probably be not very reliable, because the number of fishes examined in this group was small. Errors in otolith readings could have arisen where secondary bands and true year bands were confused. Such errors do not appear to be numerous and probably have little effect on the calculated mean lengths of each age group.

Table IV

Mean lengths and length range of whiting at each age-group in 1953-54.
Age determined by otolith readings

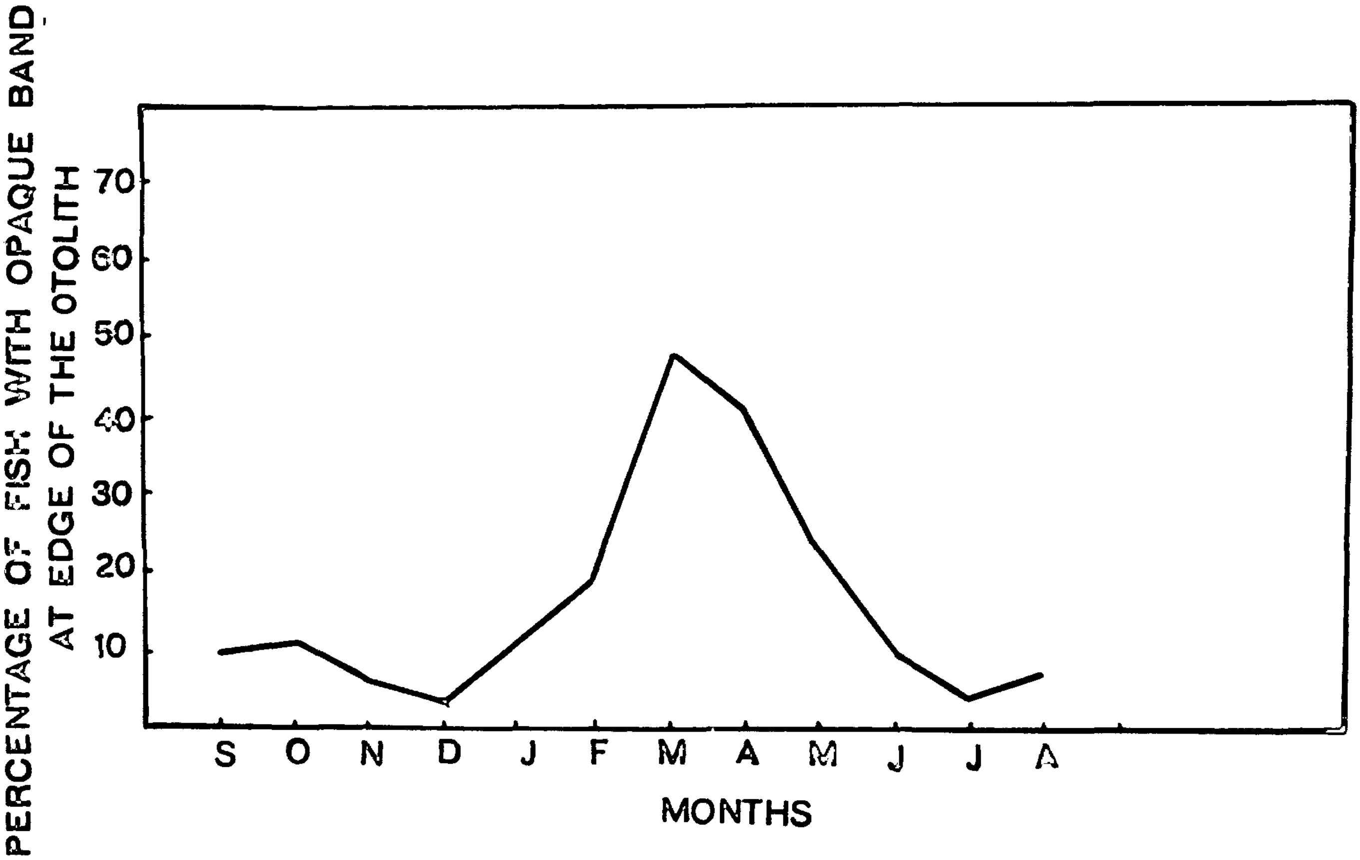
Age-group	Range in length (cm.)	Mean length (cm.)	Increase per year (cm.)
1	10-16	14.79	...
2	16-20	19.03	4.24
3	20-24	22.41	3.38
4	24-28	24.02	1.61

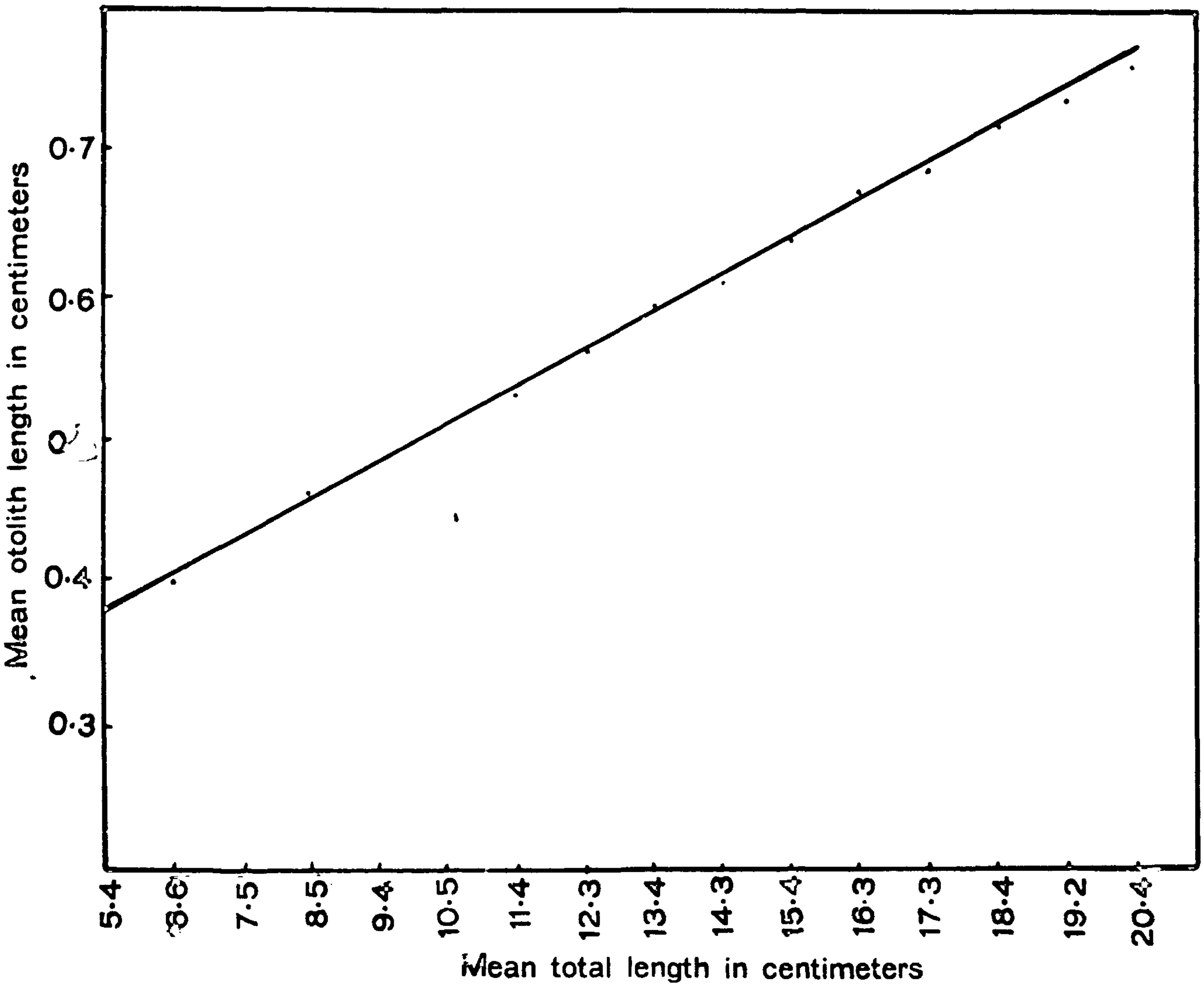
Hickling (1933) on otoliths of hake, and Dannevig (1933), on scales and otoliths of Norwegian cod, have examined the validity of the annual nature of the zones. An effort was made to fix the validity of the annual nature of the rings found on the scales of Malabar sole, Cynoglossus semifasciatus, by Seshappa and Bhimachar (1951), probably for the first time in the tropical fisheries research. The present investigation of Sillago sihama covers only a period of 12 months, and it was not possible to examine the validity of the method of age determination using all the methods described by Graham (1929). However, the two methods, namely, agreement with Peterson method and seasonal record of the ring or zone formation, were employed to fix the validity of the annual nature of the zones.

To find out whether these zones on the otoliths, though countable only in about 20-30% of cases, were put on in a regular annual sequence the structure of the edges of the otoliths of specimens in different size-groups was examined carefully, throughout the investigation. The periphery may be formed of an opaque or a translucent band, depending largely on the season of capture. Since the edge is very thin, it is sometimes difficult to distinguish whether the edge is opaque or translucent (Wallace, 1907; Jones and Hynes, 1950); but with practice it becomes possible. The relative width of the translucent bands and opaque zones varies considerably in otoliths of different fish, but when there are more than three bands on an otolith these bands are narrower and more crowded towards the edge. Text-Fig. 15 shows the condition of margin of otolith throughout the year. It was found that a particularly definite zone appeared on most otoliths about February-March, probably owing to intensive feeding during that period. More intensive work is needed to find out whether the opaque band would end abruptly as a a ring or fade out gradually as a zone. It is however often hard to differentiate between 'Zones' or 'Rings', especially in the older fish where the bands are close together. This type of study must therefore be used with

Text-Figure 15. Condition of the margin of the otolith throughout the year in Sillago sihama (Forskal)

Text-Figure 14. The relationship between total length of the fish and otolith size in Sillago sihama (Forskal)


PERCENTAGE OF FISH WITH OPAQUE BAND
AT EDGE OF THE OTOLITH
70
60
50
40
30
20
10
S
O
N
D
J
F
M
A
M
J
J
A
MONTHS


Mean otolith length in centimeters
0·7
0·6
0·4
0·3
5·4
6·6
7·5
8·5
9·4
10·5
11·4
12·3
13·4
14·3
15·4
16·3
17·3
18·4
19·2
20·4
Mean total length in centimeters

great care and only where there are other means of checking the rate of growth. The possibility that two transparent bands are laid down in one year cannot be completely excluded, although it appears unlikely.

(ii) The possible causes of zones and interzonal rings on the otoliths

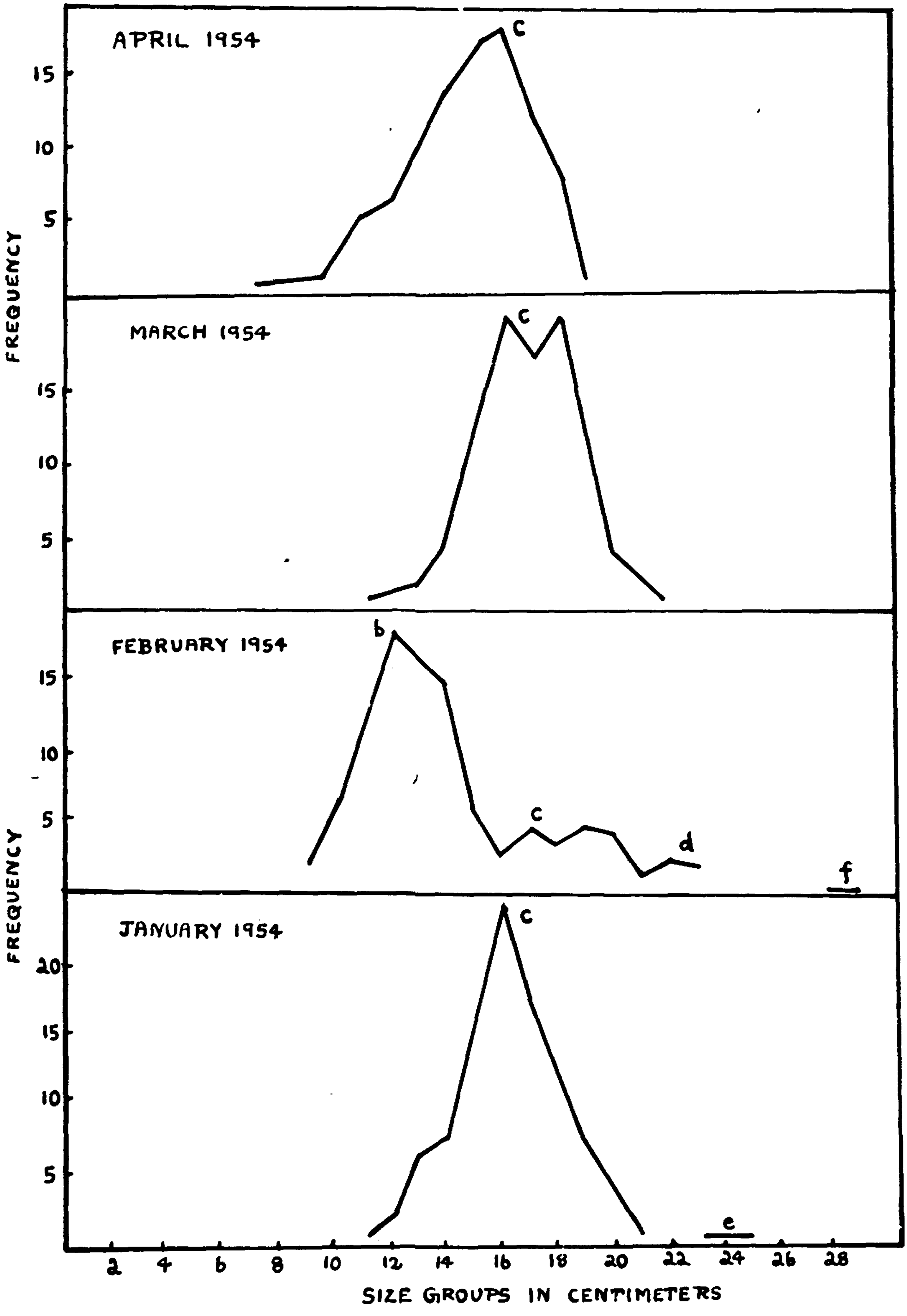
The causative factor in the formation of these growth-checks is neither clear nor conclusive. The works of Hickling (1933) on hake, Dannevig (1933) on cod and Menon (1950) on poor cod may be mentioned in this connection. Nair (1949) concluded that the scarcity of planktonic food is the main reason for the occurrence of growth-rings on the otoliths of Sardinella longiceps. Seshappa and Bhimachar (1951), working on the scales of Cynoglossus semifasciatus, concluded that the rings were formed under the influence of the south-west monsoon season and thought it appropriate to call the rings as monsoon rings. Prabhu (1953) working on Chirocentrus dorab indicated that in the immature specimens the change in environment, from the deep and offshore waters to the coastal waters, may have some effect on the formation of annuli on the scales.

During the course of the present investigation it has been noticed that there is a decrease in the rate of feeding and the amount of food consumed, with the maturation of gonads. The reduced feeding and the maturation of gonads occur simultaneously. Therefore, the suggestion is put forward now that the probable cause for the periodic formation of the rings on the otoliths of the Indian whiting is the reduction in the feeding of the fish which occurs simultaneously with the maturation of gonads.

(iii) Length frequency studies:- Length frequency studies are based on random samples of whiting collected regularly from September 1953 to August 1954. The samples were taken from the commercial catches around Mandapam and Rameshwaram Island. The majority of the analysed catches were made from the shore seine, which constitutes an important gear used along the coast for the capture of pelagic fishes. Length frequency data presented in Text Figure 16. are based on total length measurements. For the analysis of size frequencies one centimeter groups have been employed (e.g. 10 cm. size group includes specimens measuring 10.0-10.9 cm. in total length). For more accurate information the frequencies have been converted into percentages.

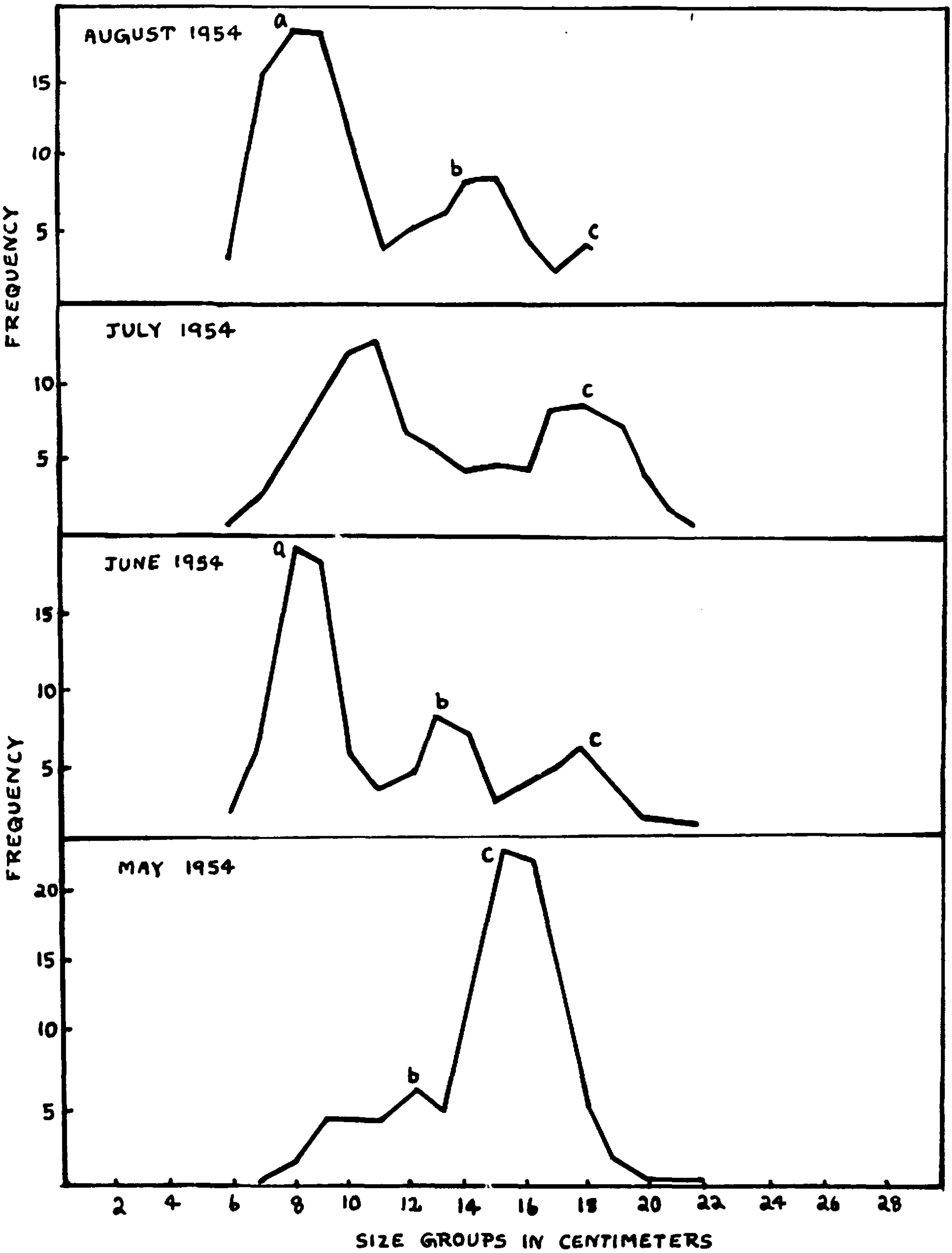
Considering the graph for September 1953, three modes are clearly seen, viz. 'a' at 3 cm., 'b' at 7 cm. and 'c' at 13 cm. Young ones upto 5 cm. in length ('a') appear during this month and they are probably the progeny of fish that spawned in August 1953. The other groups 'b' and 'c' represent those spawned in 1952 and 1951 respectively. In October 1953 besides the mode 'c', a new group 'd' appeared to be prominent. This new mode represents the 1950 brood. In January and February 1954

Text-Figure 16. Length frequency graph of the samples of *Sillago sihama* (Forskal) collected from Mandapam and Rameshwaram Island.



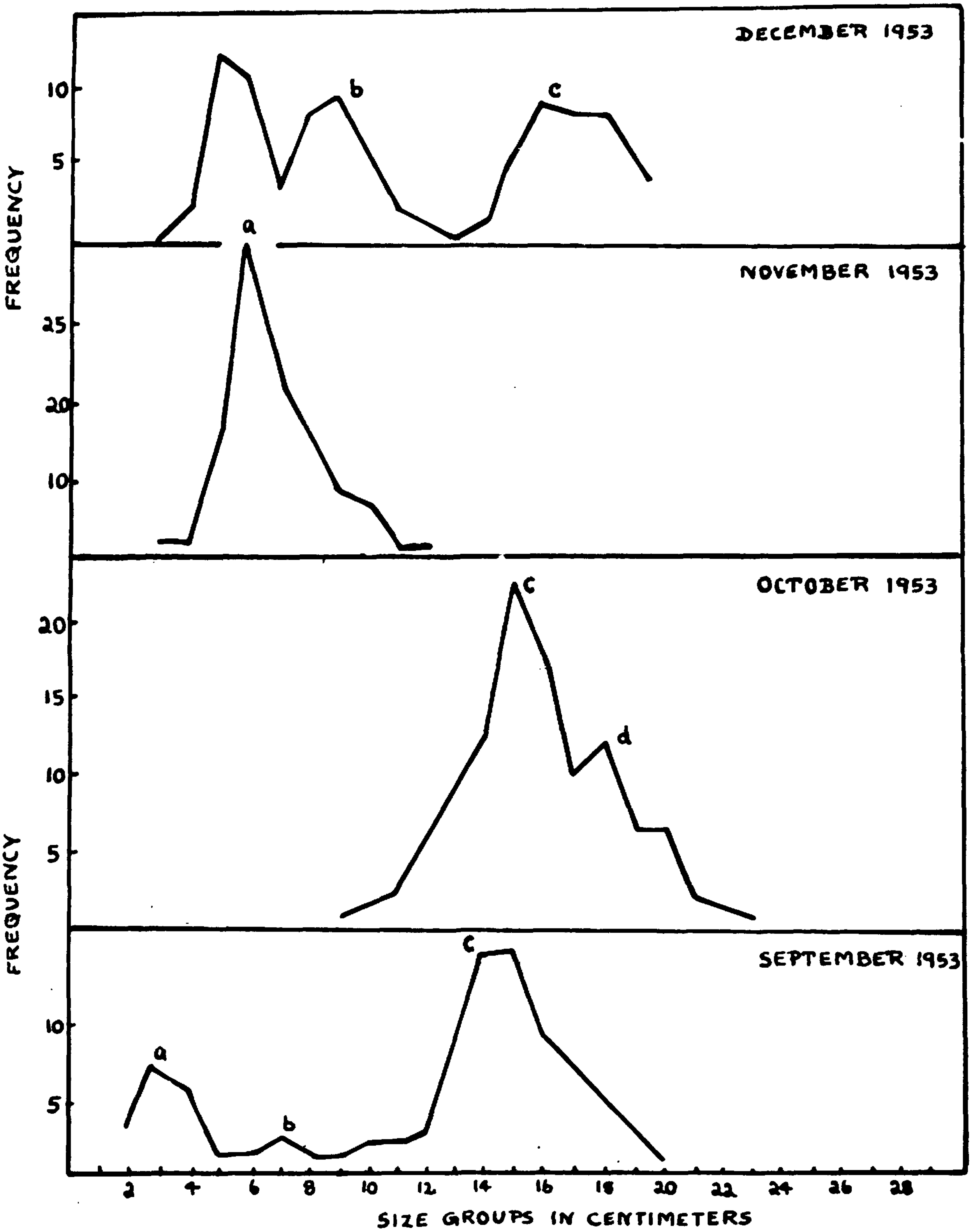
APRIL 1954
MARCH 1954
FEBRUARY 1954
JANUARY 1954
FREQUENCY
FREQUENCY
15
10
5
15
10
5
15
10
5
20
15
10
5
c
c
b
c
d
f
c
e
2 4 6 8 10 12 14 16 18 20 22 24 26 28
SIZE GROUPS IN CENTIMETERS

Text-Figure 16. Length frequency graph of the samples of <u>Sillago sihama</u> (Forskal) collected from Mandapam and Rameshwaram Island.



AUGUST 1954
JULY 1954
JUNE 1954
MAY 1954
FREQUENCY
FREQUENCY
a
b
c
c
a
b
c
c
b
15
10
5
10
5
15
10
5
20
15
10
5
2
4
6
8
10
12
14
16
18
20
22
24
26
28
SIZE GROUPS IN CENTIMETERS

Text-Figure 16. Length frequency graph of the samples of *Sillago sihama* (Forskal) collected from Mandapam and Rameshwaram Island



DECEMBER 1953
NOVEMBER 1953
OCTOBER 1953
SEPTEMBER 1953
FREQUENCY
FREQUENCY
a
b
c
d
10
5
25
20
15
2
4
6
8
10
12
14
16
18
20
22
24
26
28
SIZE GROUPS IN CENTIMETERS

small proportions of bigger specimens were obtained. A slight indication of a mode 'e' in January can be spotted at 23 cm., which represents the one that spawned in 1949. In February 1954, indications of a small mode 'f' at 29 cm. size group representing probably the 1948 brood was noticed. The groups represented by the different modes is seen increasing in size every month. Viewing the graph as a whole, we can recognise three year classes, viz. the first year group having an average length of 15.5 cm., the second year 20.5 cm. and the third year 24.5 cm. The growth rates during first and second years are thus approximately 5 cm. and 4 cm. respectively, which shows slight agreement with the age estimates obtained by the study of otoliths.

9. Fishing Methods

The whiting supports a moderate fishery along the east coast. and the fishing season in this area extends approximately from May to December. Very heavy catches, constituted mainly by fish ranging from 15 to 24 cm., frequently occur during the period mentioned above.

On the east coast, whitings are caught by _Kantivala_, _alivivala_, _iragavala_, _maravala_, _karavalai_, _kalamkattivalai_, _sippivalai_ and _veechuvalai_. Most of the whiting catches in this area are by bag-nets and shore-seine operations. The bag-net is of conical shape and with mesh of ½ inch. The net varies in length from 36 to 42 feet, with a mouth opening of about the same diameter. The net is operated from two catamarans and at a depth of 3 to 6 fathoms. Fishes are caught by stake nets also, which are 1½ feet high, planted within the shore during the low tide, especially during the new moon and full moon days. During high tide sea-water flows above and over the net, carrying the fish along, but when the tide recedes most of the fishes are trapped in the net. The operation of sippivalai was found to be the most successful method for the capture of whiting since the fish bury themselves in mud when they feel the shore-seine over them and leave the mud and swim off when it is removed. On the west coast, the main types of nets which are being operated for the capture of whiting are periavala, kattuvala and veechuvala. Hooks and lines are also used with prawns and bristle worms as baits.

PART II

THE BIOLOGY OF THE LONG FINNED HERRING, OPISTHOPTERUS TARDOORE (CUVIER)

C O N T E N T S

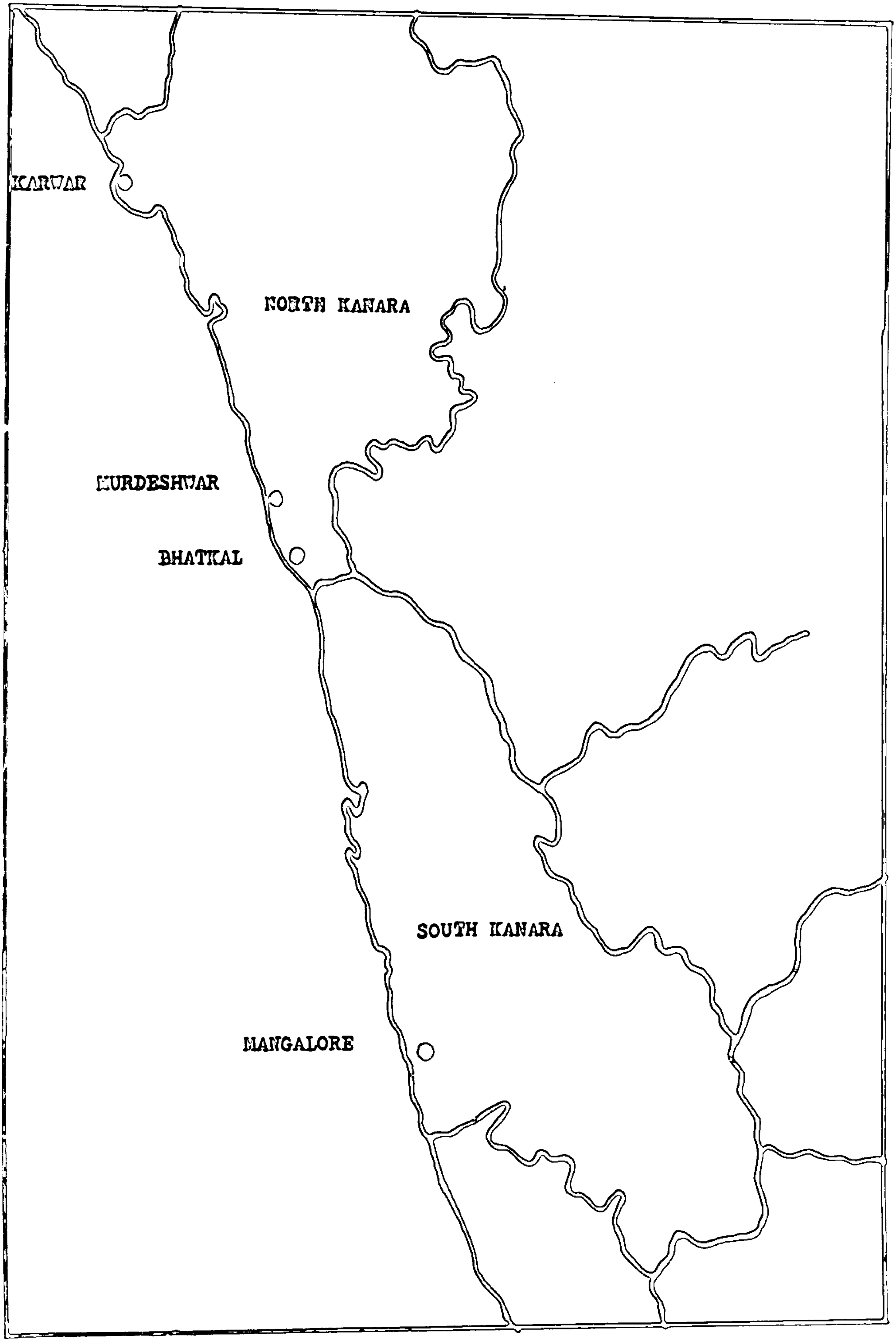
The biology of the long finned herring, <u>Opisthopterus tardoore</u> (Cuvier)

1. Material and Methods

<u>Study on morphometry</u>: Four centres for the collection of samples from the Kanara coast were selected (Text-Figure 1.). In all 695 specimens were collected from these centres, Karwar = 350, Murdeshwar = 124, Bhatkal = 115 and Mangalore = 106. In order to avoid errors in body measurements due to shrinkage, all specimens from different localities were treated similarly as they were kept preserved in 5% formaldehyde solution for about two weeks, before making measurements. The various body measurements studied are shown in Text Figure 2. They were as follows:

1.	TL	Total length.
2.	SL	Standard length.
3.	HL	Head length.
4.	LTA	Length upto anus.
5.	BL	Body length.
6.	MDP	Maximum body depth along the pectoral fin.
7.	MDA	Maximum body depth along the anal fin.

Text-Figure 1. Map showing the different places of collection on the Kanara coast.


KARWAR
NORTH KANARA
MURDESHWAR
BHATKAL
SOUTH KANARA
MANGALORE

8. DCP Depth of caudal peduncle.
9. IS Interorbital space.
10. DE Diameter of the eye.
11. LM Length of maxillary.
12. LP Length of pectoral.
13. UJD Upper jaw to the dorsal fin.
14. HH Height of head.

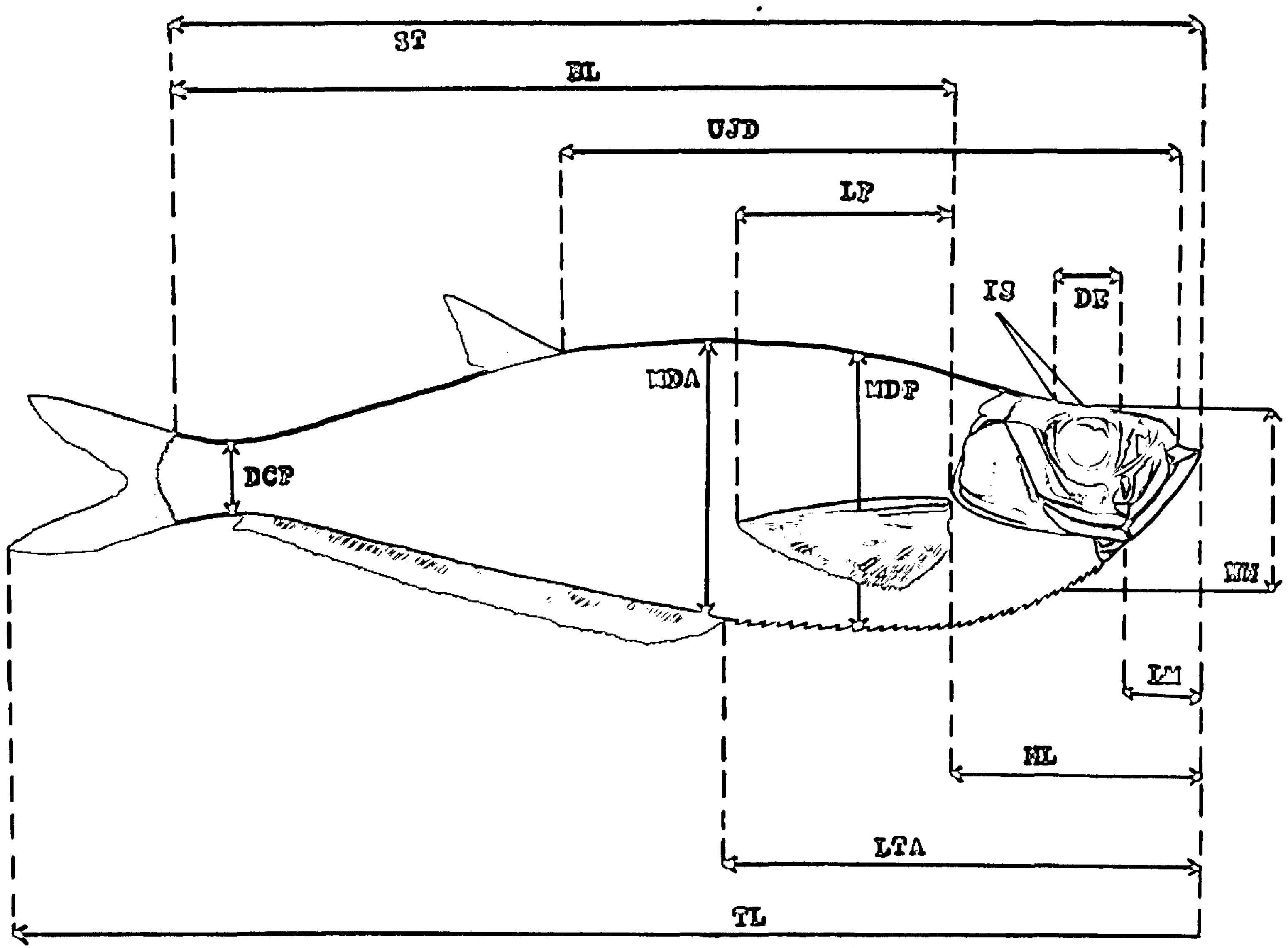
The measurements of 1 to 5 and of 11 to 14 were carried out by placing the fish on the measuring board with its scale graduated in millimeters. Other measurements were carried out with the help of a pair of dividers having a scale mechanism. All measurements were recorded to the nearest 0.5 mm. below.

<u>Length frequency studies</u>:- For the purpose of this study, the total length (TL) was taken into account. A sample of 50 fishes was measured at a time and arranged in 10 mm groups. The total number of measurements and the samples obtained during different years are shown below:

YEAR	NUMBER MEASURED	NUMBER OF SAMPLES
1956	2106	24
1957	2952	29
1958	1922	23
1959	1343	12
1960	981	19

Text-Figure 2. Morphometric measurements of different body parts of <u>Opisthopterus</u> <u>tardoore</u> (Cuvier.)

TL	:	Total Length
SL	:	Standard Length
UJD	:	Upper jaw to the dorsal fin
DE	:	Diameter of the eye
IS	:	Interorbital space
HH	:	Height of head
LM	:	Length of maxillary
HL	:	Head length
LP	:	Length of pectoral
MDA	:	Maximum body depth along the anal fin
MDP	:	Maximum body depth along the pectoral fin
BL	:	Body length
LTA	:	Length upto anal
DCP	:	Depth of caudal peduncle



TL
LTA
HL
LJ
MW
DE
IS
MDP
MDA
LP
UJD
BL
SL
DCP

A total of 9304 specimens from 107 samples were measured during the period of investigation. As the total differed from month to month, the numbers of each size group were converted into percentages to facilitate comparison in different months.

<u>Maturity and spawning</u>: Fishes were collected from Karwar and neighbouring fishing villages. All fishes were measured to the nearest millimeter, weighed to the nearest gram and their ovaries were dissected out carefully for examination. A small portion of the ovary was teased on a micro-slide and the ova thus separated were examined under a microscope to determine the appropriate stage of development. The criterion of such an assessment was based on the size of the ovum, the condition of the yolk and the presence and absence of the single oil globule. Ovaries were then preserved in 5% formaldehyde solution for subsequent examination.

<u>Spawning periodicity</u>: For this study, samples of ova were obtained by teasing a small portion of the ovary which were preserved in 2% formaldehyde solution. Before making measurements the stage of maturity of gonads was determined by gross examination of the eye. The diameters of all the ova were measured with the help of an ocular micrometer. Owing to lack of symmetry caused in the eggs due to preservation, the micrometer scale was placed horizontally and the

diameter of each egg was measured by keeping the egg parallel to the micrometer scale. This method avoided selection of the longest or the shortest diameter in measuring the ova. In drawing the frequency polygons, the diameter frequencies were grouped into 3 micrometer division groups, as 16-18, 19-21, 22-24 and so on.

<u>Food analysis</u>: The stomach of each fish was carefully removed and preserved in 5% formaldehyde solution. At the time of examination it was split open and the contents washed with water in a petri-dish. The volume of the gut content was measured by displacement method. Enumeration method was followed in determining the composition of the stomach content: i.e. one c.c. of the made up gut content which was well stirred was taken by means of a graduated pipette and spread over a counting chamber. The number of organisms belonging to each species was counted under a binocular microscope and recorded.

2. A morphometric study of the stocks of the long finned herring, off Karwar, Murdeshwar, Bhatkal and Mangalore.

Slight changes in the morphometric measurements have been reported if the population constitutes more than one independent stock. The reason for such changes may probably be genetic or phenotypic. These small changes in any particular character cannot be judged easily and hence statistical methods have to be employed to test the significance of any differences. Firstly, an attempt to compare the samples was made by comparing the mean ratios of the same character, in relation to another taken as standard, for example, the standard length. But, as most of the characters are size specific, a comparison of means would not lead to conclusive results, unless all samples happen to contain such specimens which are of the same size. Hence, the regressions were compared after an analysis of covariance. As can be seen from the scatter diagrams shown in Text Figures 3, 4, 5, 6 and 7 for one locality, the regressions of all thirteen characters on standard length were found to be linear. The scatter diagram for the other three localities also show a similar trend. Hence, comparisons of the slope of the regression will not be vitiated even if the specimens from ~~the~~ different localities are not of the same size. The size distribution of the length collected at different centres have been shown in Text Figure 8.

As indicated earlier, the procedure followed is of comparing the regressions of different characters with reference to the standard character from different places. One regression of the variable character denoted by Y's on the standard character (X)- standard length - is assumed to be linear. Mean sum of squares due to deviations of individual regressions from common regression is tested against residual mean sum of squares. A significant value of this ratio compared with F at a certain level with the corresponding degree of freedom will indicate differences in regression coefficient from different places. The values showing the means and regression coefficient of Y's on X are shown in Table No.1. All measurements were taken into account and these are referred to as follows:

Standard length	X
Total length	Y_1
Head length	Y_2
Length upto anus	Y_3
Body length	Y_4
Maximum body depth along the pectoral fin	Y_5
Maximum body depth along the anal fin	Y_6
Depth of caudal peduncle	Y_7
Interorbital space	Y_8
Diameter of the eye	Y_9
Length of maxillary	Y_{10}

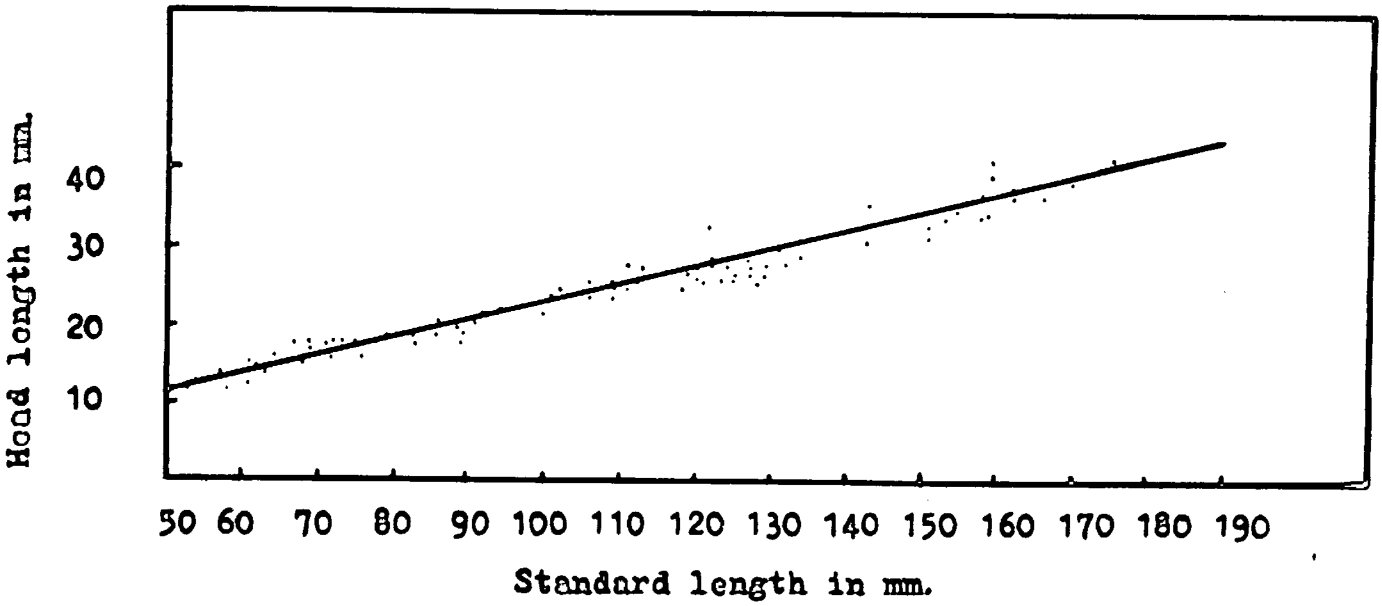
Length of pectoral	Y_{11}
Upper jaw to dorsal fin	Y_{12}
Height of head	Y_{13}

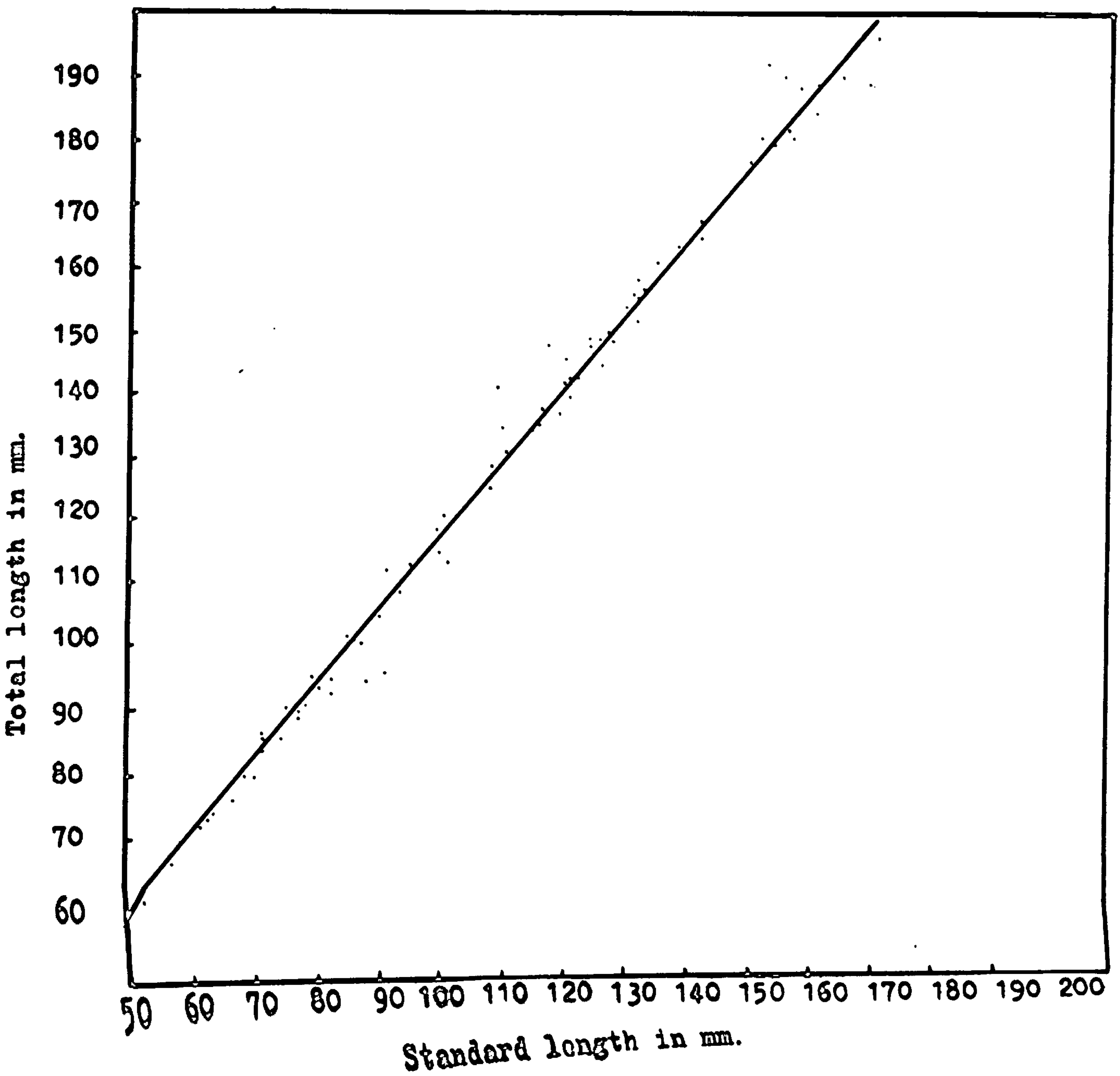
Table No.I

THE MEANS AND REGRESSION COEFFICIENTS OF Y's ON X.

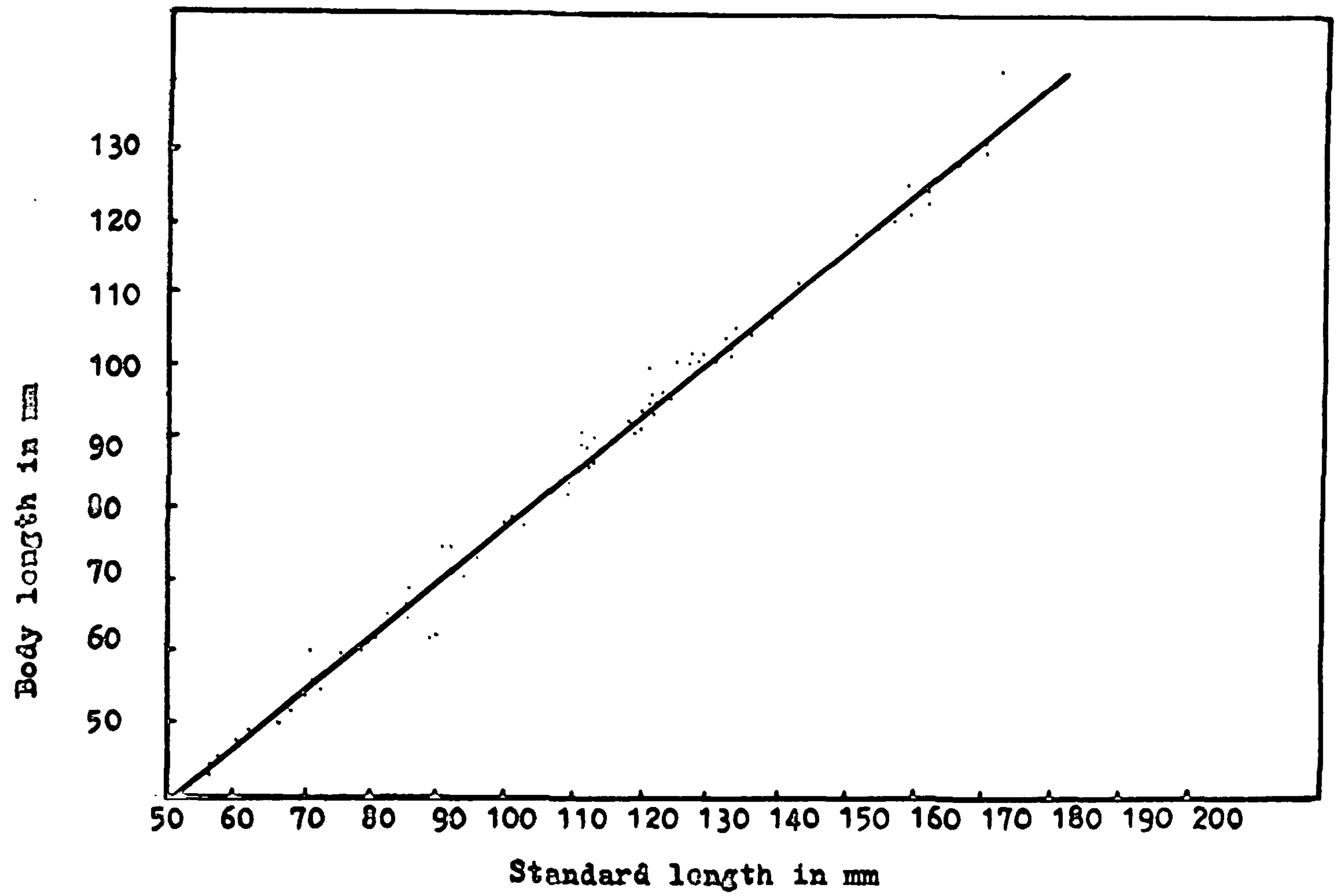
CHARACTERS	KARWAR		BHATKAL		MURDESHWAR		MANGALORE	
	Mean	'b'	Mean	'b'	Mean	'b'	Mean	'b'
STANDARD LENGTH (X)	90.3170	-	140.1130	-	131.7016	-	129.4057	-
TOTAL LENGTH (Y_1)	104.6400	1.237340	163.6261	1.096448	153.6129	1.094409	150.6792	1.121734
HEAD LENGTH (Y_2)	20.4143	.220021	31.5217	.105475	30.2984	.218430	29.6038	.226105
LENGTH UPTO ANUS (Y_3)	45.1886	.567830	72.8000	.538664	68.5091	.534553	68.0000	..550949
BODY LENGTH (Y_4)	69.7943	.924540	108.6870	.777101	101.5242	.789250	99.7358	.370572
MAXIMUM BODY DEPTH ALONG THE PECTORAL FIN (Y_5)	28.2143	.303261	41.4000	.270157	39.5161	.224578	40.1887	.309686
MAXIMUM BODY DEPTH ALONG THE ANAL FIN (Y_6)	24.9743	.318512	36.8522	.249828	34.9839	.196767	36.0000	.295778
DEPTH OF CAUDAL PEDUNCLE (Y_7)	7.5429	.085314	10.8435	.070946	10.4274	.043905	10.9245	.064382
INTERORBITAL SPACE (Y_8)	3.4743	.034900	3.5304	.017628	3.7097	.024509	3.7358	.020927
DIAMETER OF THE EYE (Y_9)	6.8971	.059855	10.5130	.012416	10.3387	.036435	9.5755	.064339
LENGTH OF MAXILLARY (Y_{10})	10.4829	.116177	16.2957	.106881	15.6613	.104738	15.1509	.116770
LENGTH OF PECTORAL (Y_{11})	20.2314	.240263	34.6609	.182185	31.0887	.197124	29.8208	.217715
UPPER JAW TO DORSAL FIN (Y_{12})	54.5000	.712460	86.8788	.566025	81.5403	.550408	79.3491	.619524
HEIGHT OF HEAD (Y_{13})	14.6800	.133623	22.9217	.118592	21.2581	.081459	18.4623	.121765

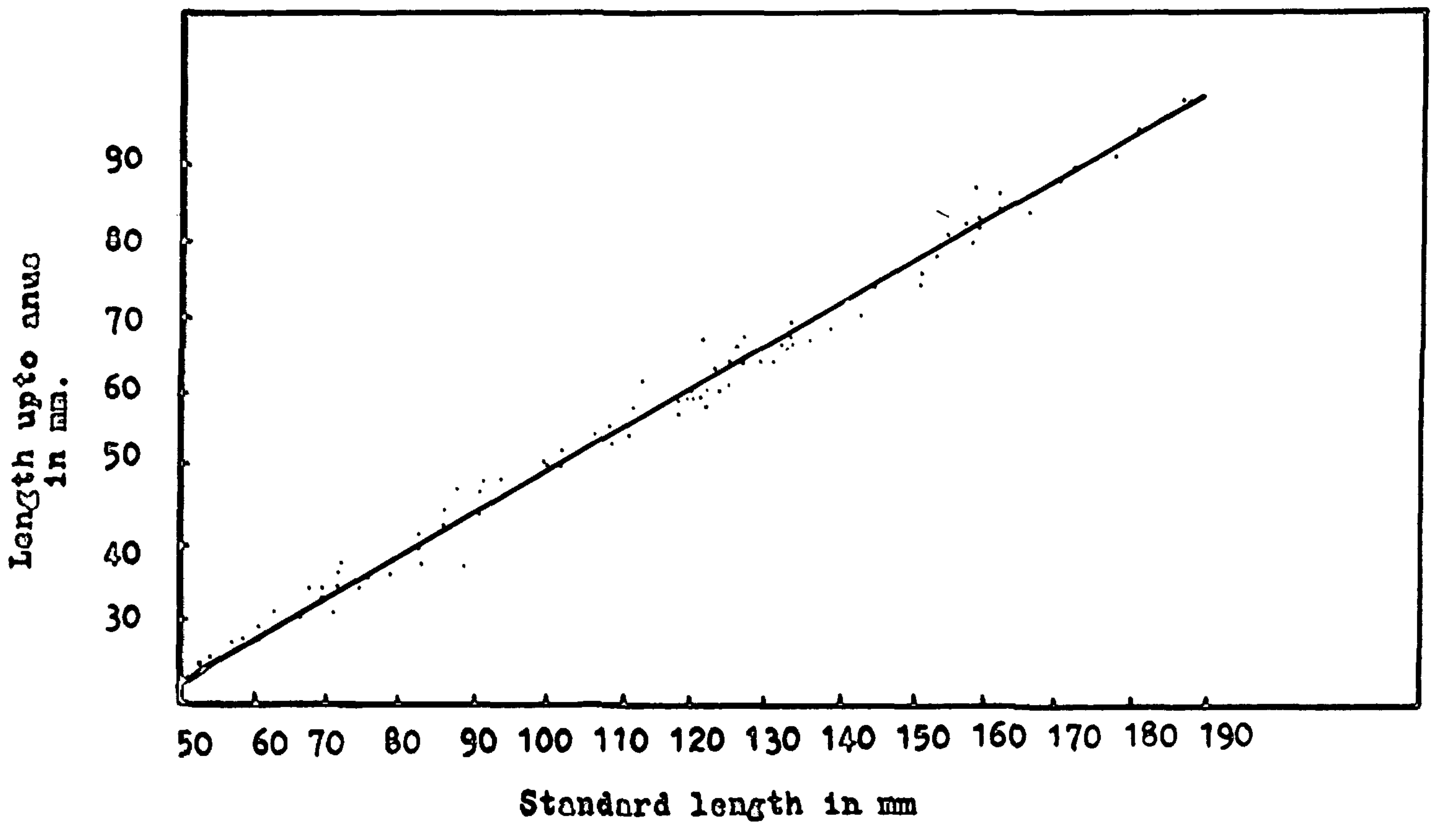
Text-Figure 3. The regressions of total length and head length on standard length for Karwar showing the distribution of individual variants.


Head length in mm.
10
20
30
40
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190
Standard length in mm.

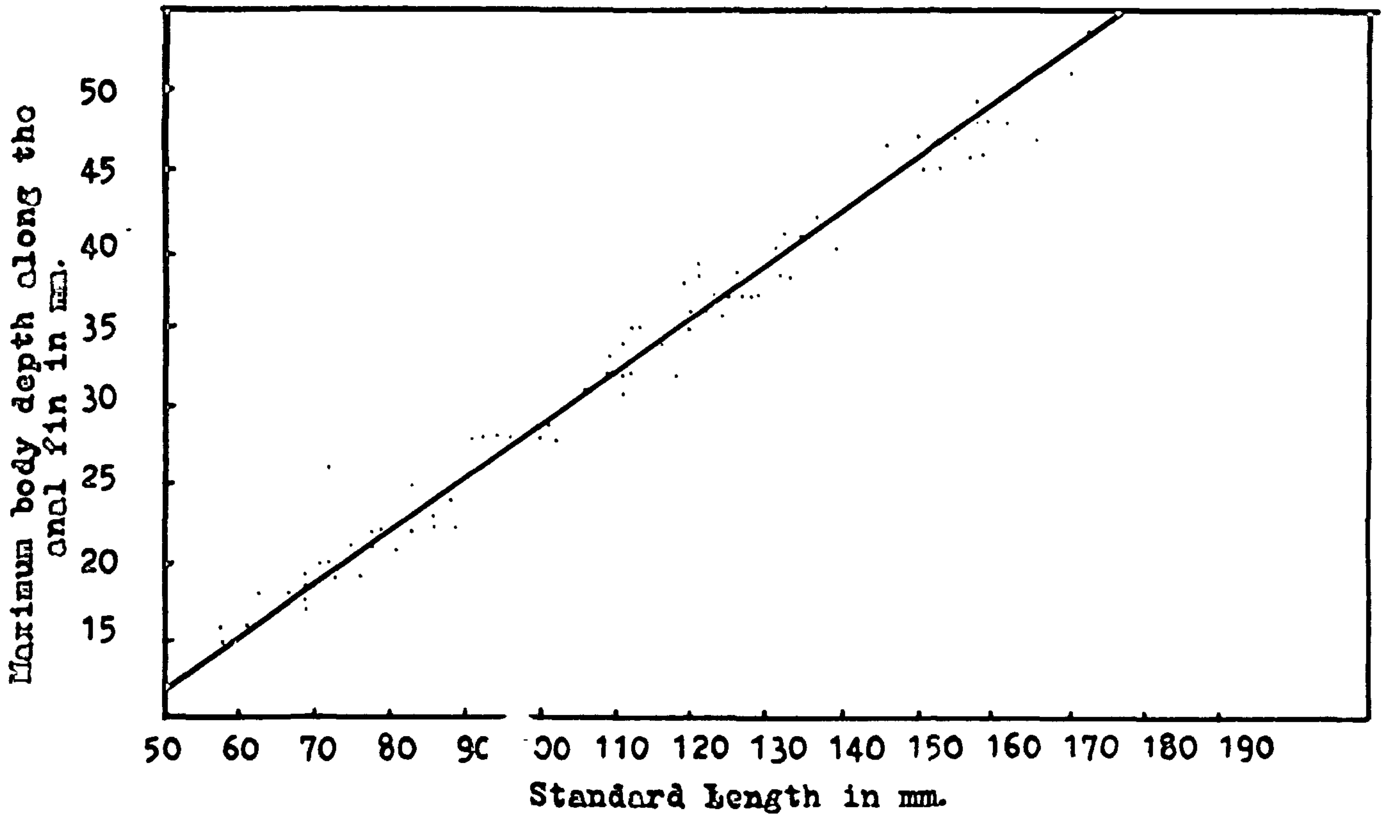

Total length in mm.
60
70
80
90
100
110
120
130
140
150
160
170
180
190
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Standard length in mm.

Text-Figure 4. The regressions of length upto anus and body length on standard length for Karwar showing the distribution of individual variants.

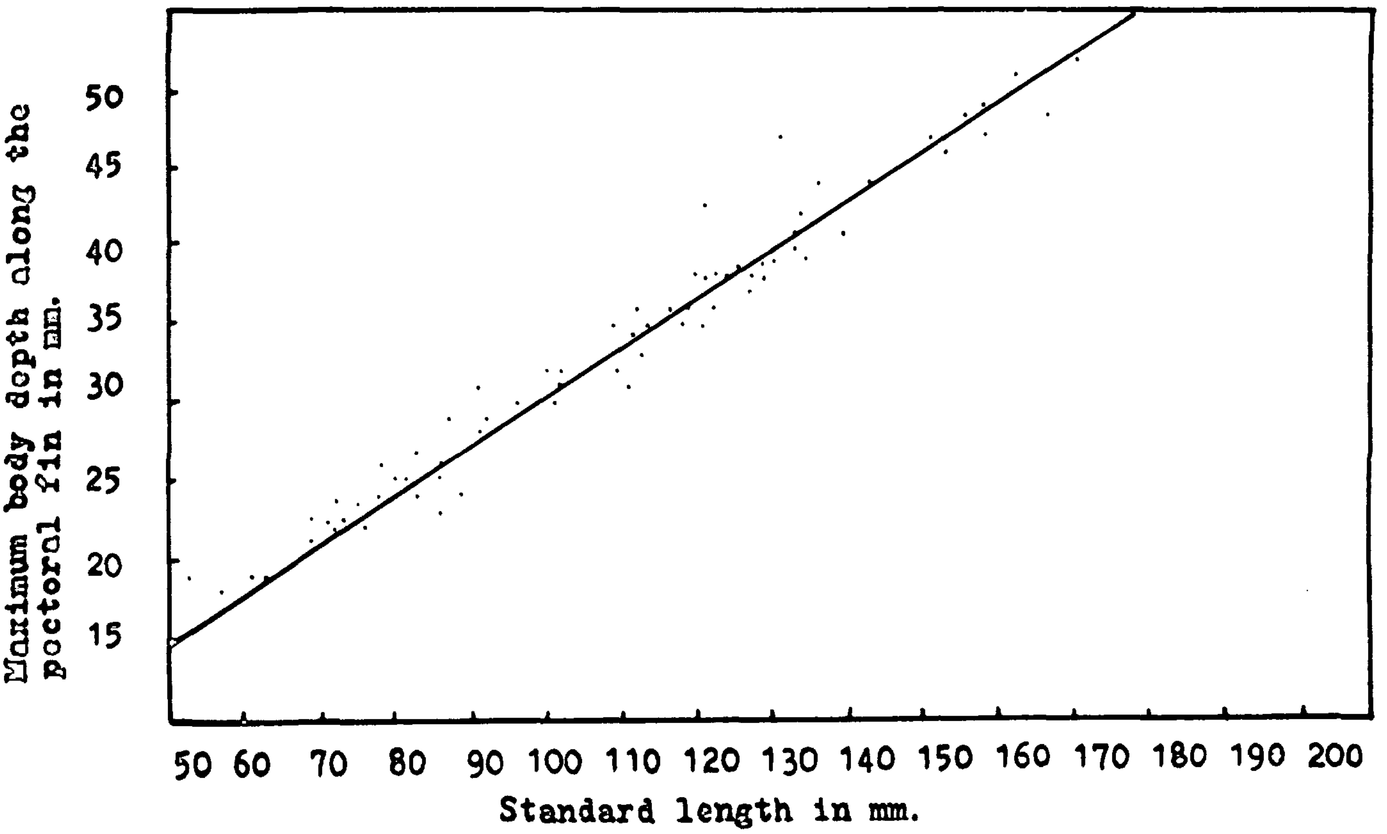

130
120
110
100
90
80
70
60
50
Body length in mm
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Standard length in mm


90
80
70
60
50
40
30
Length upto anus in mm.
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190
Standard length in mm

Text-Figure 5. The regression of maximum body depth along the pectoral fin and maximum body depth along the anal fin on standard length for Karwar showing the distribution of individual variants.

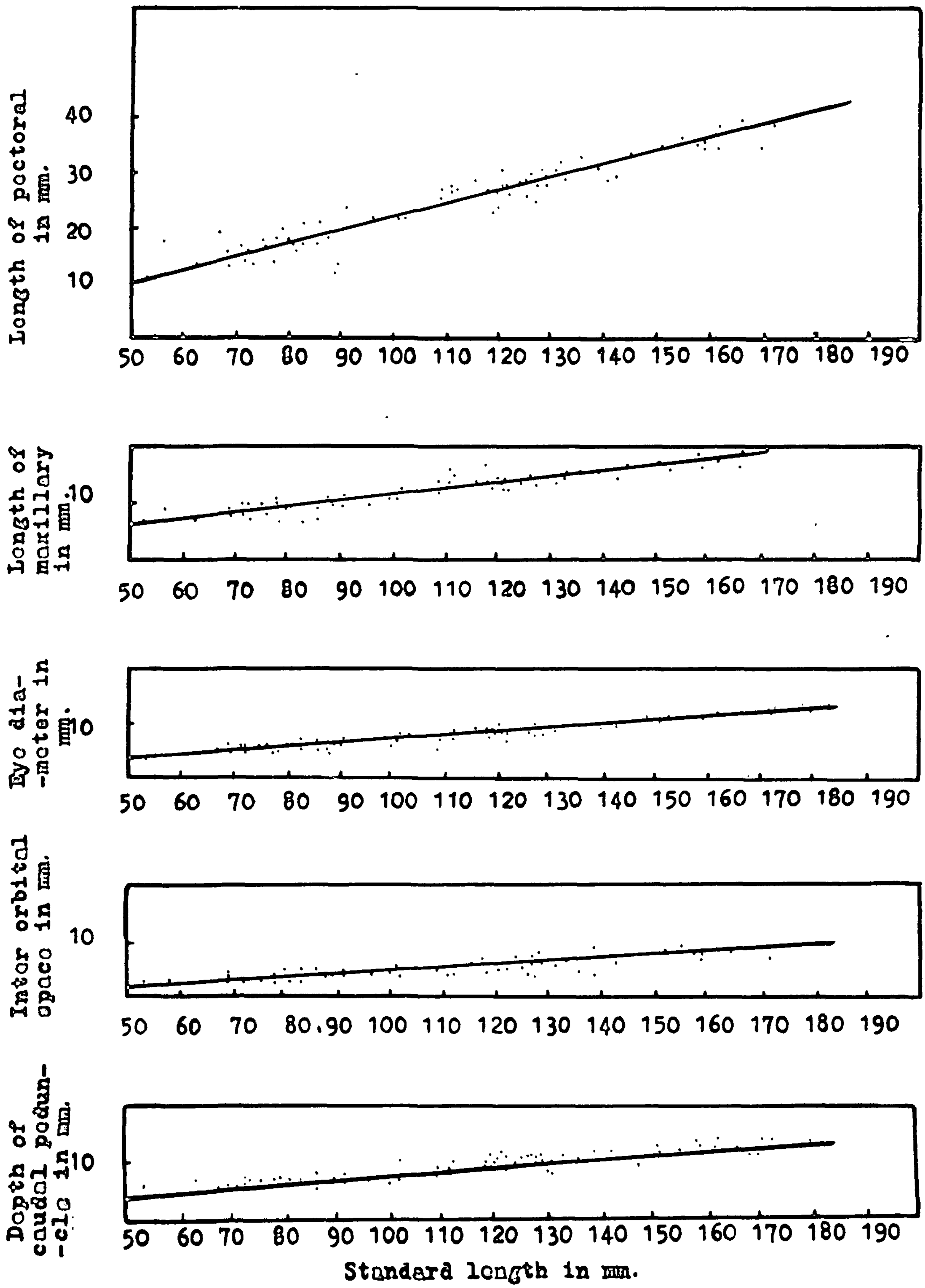


Maximum body depth along the anal fin in mm.
50
45
40
35
30
25
20
15
50
60
70
80
90
110
120
130
140
150
160
170
180
190
Standard Length in mm.

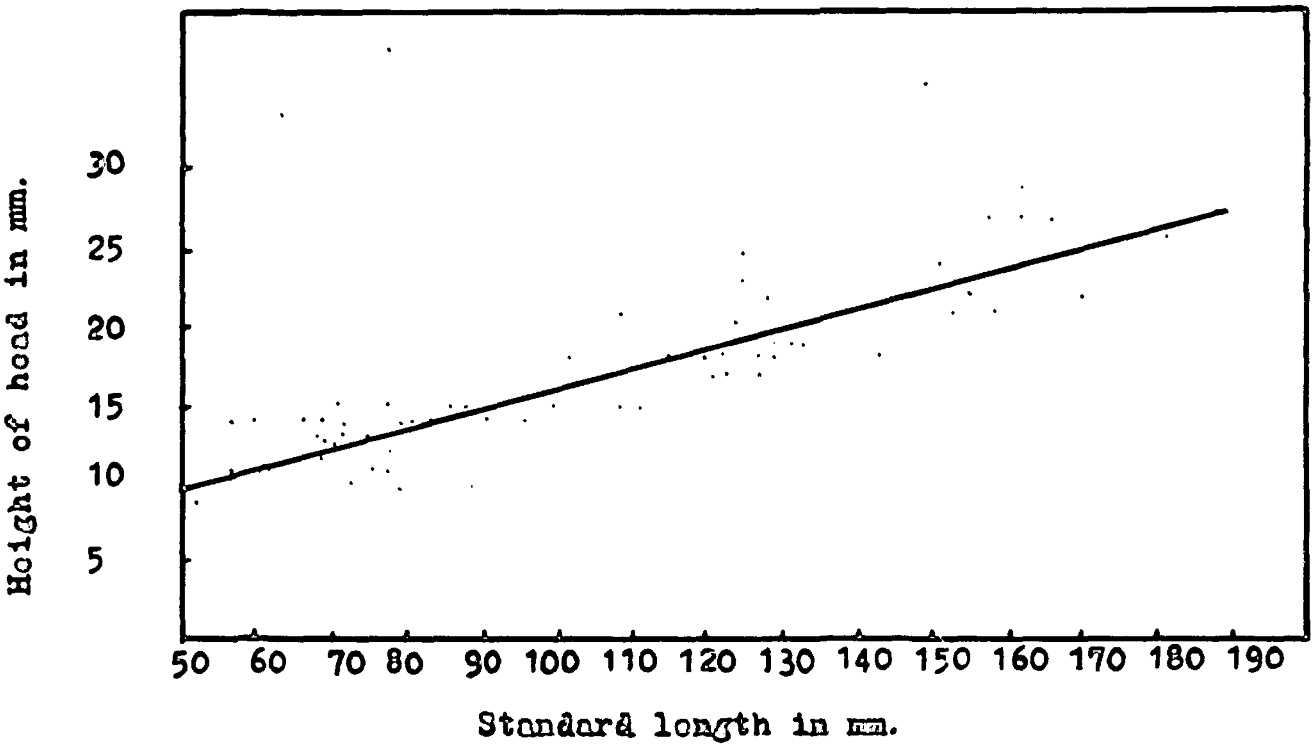


Maximum body depth along the pectoral fin in mm.
50
45
40
35
30
25
20
15
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
Standard length in mm.

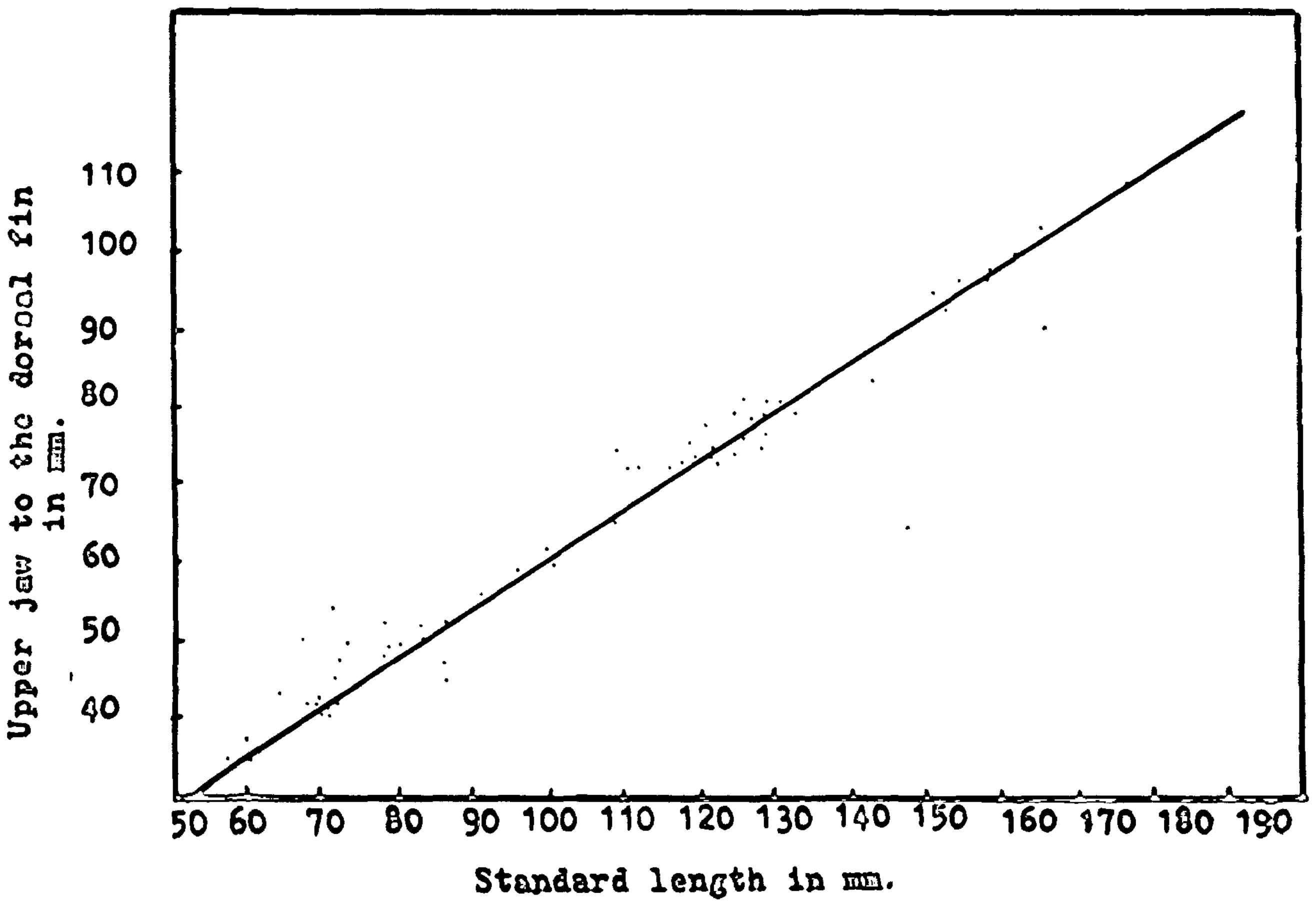
Text-Figure 6. The regressions of depth of caudal peduncle, interorbital space, diameter of the eye, length of maxillary and length of pectoral on standard length for Karwar showing the distribution of individual variants.


Length of pectoral in mm.
40
30
20
10
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190
Length of maxillary in mm.
10
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190
Eye dia-meter in mm.
10
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190
Inter orbital space in mm.
10
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190
Depth of caudal pedun-cle in mm.
10
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190
Standard length in mm.

Text-Figure 7. The regression of upper jaw to the dorsal fin and height of head on standard length for Karwar showing the distribution of individual variants.

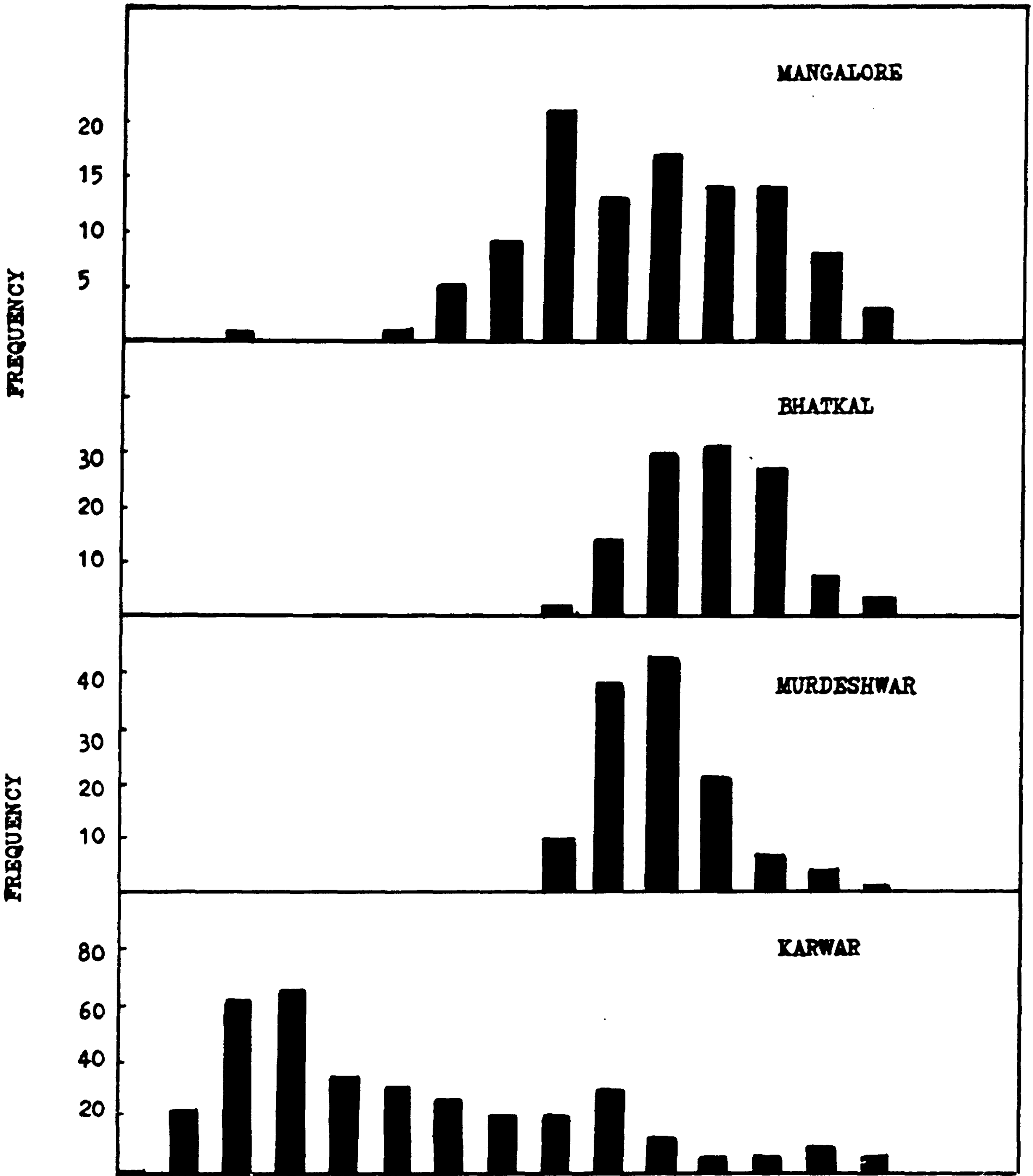


Height of head in mm.
5
10
15
20
25
30
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
Standard length in mm.



Upper jaw to the dorsal fin in mm.
40
50
60
70
80
90
100
110
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
Standard length in mm.

Text-Figure 8. Length frequency distribution polygons for specimens collected at Karwar, Murdeshwar, Bhatkal and Mangalore.


MANGALORE
BHATKAL
MURDESHWAR
KARWAR
FREQUENCY
FREQUENCY
20
15
10
5
30
20
10
40
30
20
10
80
60
40
20
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190
SIZE GROUPS IN MMS

Analysis of covariance between Karwar, Murdeshwar, Bhatkal and Mangalore.

The body measurements of specimens indicate the possibility of seasonal differences in some of the morphometric measurements taken at different centres. It was decided to compare the samples from different localities to determine if they are homogeneous or heterogeneous. For this, the data of various centres were pooled and treated as one sample. Thus, the morphometric measurements of 695 specimens from four different localities are analysed by adopting the same technique of the analysis of covariance. The corrected sum of squares, products and regression coefficients are given in respect of thirteen characters on standard length. They are shown in Table Nos.2 to 14. Based on this data, the analysis of covariance for all the characters was carried out and the results are shown in Tables 2-14. From the analysis it is clear that the regressions of ten characters namely total length, head length, body length, maximum body depth along the pectoral fin, maximum body depth along the anal fin, depth of caudal peduncle, interorbital space, diameter of the eye, length of pectoral and upper jaw to the dorsal fin on standard length show highly significant differences at 1% level. The remaining three characters ie. length upto anus, length of maxillary and height of head do not show significant differences at 5% level. From such an analysis it becomes clear that the samples from different places do not come from identical stocks. The summary of the results of the analysis of covariance of different morphometric measurements from all the four places combined are given in Table No.15.

Table No.2

Analysis of covariance between Karwar, Bhatkal, Murdeshwar and Mangalore.

TOTAL LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	Sx^2	b	bSxy	d.f.
Karwar	404986.64	324010.96	261859.31	1.237340	400914.89	348
Bhatkal	18826.68	15279.65	13935.59	1.096448	16753.38	113
Murdeshwar	16223.48	13837.73	12644.01	1.094481	15144.12	122
Mangalore	52775.82	45938.42	40953.01	1.121734	51539.38	104
	492812.62	399064.76	329391.92		484351.77	687

bw = 1.211519 bwSxyw = 483474.83

$$F = \frac{876.94/3}{8460.85/687} = 23.74(XX)$$

XX = Significant at 1% level

Table No.3.

Analysis of covariance between Karwar, Bhatkal, Murdeshwar and Mangalore.

HEAD LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	13242.83	57614.56	.220021	12676.36	348
Bhatkal	792.84	1469.85	.105475	155.03	113
Murdeshwar	883.91	2761.83	.218430	603.27	122
Mangalore	2517.28	9259.68	.226105	2093.61	104
	17436.86	71105.92		15528.27	687

bw = .215870 bwSxyw = 15349.63

$$F = \frac{178.64/3}{1908.59/687} = \frac{59.55}{2.77} = 21.50 \quad (XX)$$

XX = Significant at 1% level

Table No.4

Analysis of covariance between Bhatkal, Karwar, Murdeshwar and Mangalore.

LENGTH UPTO ANUS ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	85660.57	148693.17	.567830	84432.35	348
Bhatkal	5036.40	7506.60	.538664	4043.53	113
Murdeshwar	4670.69	6758.89	.534553	3612.99	122
Mangalore	14190.00	22563.00	.550949	12431.08	104
	109557.66	185521.66		104519.95	687

bw = .563224 bwSxyw = 104490.99

$$F = \frac{28.96/3}{5037.71/687} = \frac{9.65}{7.33} = 1.31 \text{ (N.S.)}$$

N.S = Not significant

Table No.5

Analysis of covariance between Karwar, Bhatkal, Murdeshwar and Mangalore.

BODY LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	178238.24	215915.38	.824540	178030.88	343
Bhatkal	8944.19	10829.37	.777101	8415.53	113
Murdeshwar	8402.85	9979.29	.789250	7876.16	122
Mangalore	22936.12	15176.03	.370572	5623.80	104
	218521.40	251900.07		199946.37	687

bw = .764742 bwSxyw = 192638.01

$$F = \frac{7308.36/3}{18575.93/687} = \frac{2436.12}{27.03} = 90.12\ (XX)$$

XX = Significant at 1% level

Table No.6

Analysis of covariance between Karwar, Bhatkal, Murdeshwar and Mangalore.

MAXIMUM BODY DEPTH ALONG THE PECTORAL FIN ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Karwar	26428.79	79411.76	.303261	24082.41	348
Bhatkal	1417.60	3764.80	.270157	1017.09	113
Murdeshwar	1005.11	2839.57	.224578	637.70	122
Mangalore	4246.14	12682.60	.309686	3927.62	104
	33097.64	98698.73		29664.82	687

$bw = .299639 \qquad bwSxyw = 29573.93$

$$F = \frac{90.84/3}{3432.82/687} = \frac{30.28}{4.998} = 6.05 \text{ (XX)}$$

XX = Significant at 1% level

Table No.7

Analysis of covariance between Karwar, Bhatkal, Murdeshwar and Mangalore.

MAXIMUM BODY DEPTH ALONG THE ANAL FIN ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	27262.64	83405.40	.318512	26565.62	348
Bhatkal	1242.38	3481.50	.249828	869.78	113
Murdeshwar	802.84	2487.93	.196767	489.54	122
Mangalore	3880.00	12113.00	.295778	3582.75	104
	33187.86	101487.83		31507.09	687

bw = .308106   bwSxyw = 31269.00

$$F = \frac{238.69/3}{1680.17/687} = \frac{79.56}{2.445} = \underline{32.53}\,(XX)$$

XX = Significant at 1% level

Table No.8

Analysis of covariance between Karwar, Bhatkal, Murdeshwar and Mangalore.

DEPTH OF CAUDAL PEDUNCLE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	2105.74	22340.39	.085314	1905.94	348
Bhatkal	187.16	988.68	.070946	70.14	113
Murdeshwar	130.37	555.13	.043905	24.37	122
Mangalore	291.43	2636.63	.064382	169.75	104
	2714.70	26520.83		2170.20	687

$bw = .0805145 \qquad bwSxyw = 2135.31$

$$F = \frac{34.89/3}{544.50/687} = \frac{11.63}{.792} = 14.68 \text{ (XX)}$$

XX = Significant at 1% level

Table No.9

Analysis of covariance between Karwar, Bhatkal, Murdeshwar and Mangalore.

INTERORBITAL SPACE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	641.26	9138.90	.034901	318.96	348
Bhatkal	16.66	245.66	.017628	4.33	113
Murdeshwar	47.54	309.89	.024509	7.59	122
Mangalore	46.62	857.03	.020927	17.93	104
	752.07	10551.48		348.81	687

bw = .032033 bwSxyw = 338.00

$$F = \frac{10.81/3}{403.26/687} = \frac{3.60}{.587} = 6.13 \text{ (XX)}$$

XX = Significant at 1% level

Table No.10

Analysis of covariance between Karwar, Bhatkal, Murdeshwar and Mangalore.

DIAMETER OF THE EYE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	1248.40	15673.77	.059855	938.15	348
Bhatkal	72.78	173.03	.012416	2.15	113
Murdeshwar	214.79	460.69	.036435	16.79	122
Mangalore	239.87	2634.89	.064339	169.63	104
	1775.84	18942.38		1126.62	687

bw = .057507 bwSxyw = 1089.32

$$F = \frac{37.30/3}{649.22/687} = \frac{12.43}{.945} = 13.15 \text{(XX)}$$

XX = Significant at 1% level

Table No.11

Analysis of covariance between Karwar, Bhatkal, Murdeshwar and Mangalore.

LENGTH OF MAXILLARY ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	3945.24	30422.05	.116177	3534.34	348
Bhatkal	238.17	1489.45	.106881	159.19	113
Murdeshwar	225.76	1324.31	.104738	138.71	122
Mangalore	803.65	4782.10	.116770	558.41	104
	5212.82	38017.91		4390.65	687

$bw = .115418 \qquad bwSxyw = 4387.95$

$$F = \frac{2.70/3}{822.17/687} = \frac{.90}{1.2} = .75 \text{ (N.S.)}$$

N.S = Not significant.

Table No.12

Analysis of covariance between Karwar, Bhatkal, Murdeshwar and Mangalore.

LENGTH OF PECTORAL ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	15605.46	62915.21	.240263	15116.20	348
Bhatkal	791.66	2538.86	.182185	462.54	113
Murdeshwar	1380.06	2492.44	.197124	491.32	122
Mangalore	3417.45	8916.09	.217715	1941.16	104
	21194.63	76862.60		18011.22	687

bw = .233347 bwSxyw = 17935.66

$$F = \frac{75.56/3}{3183.41/687} = \frac{25.19}{4.63} = 5.44(XX)$$

XX = Significant at 1% level

Table No.13

Analysis of covariance between Karwar, Bhatkal, Murdeshwar and Mangalore.

UPPER JAW TO DORSAL FIN ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	118048.50	174775.50	.667441	116652.00	348
Bhatkal	6664.91	7887.90	.566026	4464.79	113
Murdeshwar	4477.03	6959.36	.550408	3830.46	122
Mangalore	16533.72	25371.40	.619524	15718.19	104
	145724.16	214994.16		140665.44	687

bw = .652700 bwSxyw = 140326.58

$$F = \frac{338.86/3}{5058.72/687} = \frac{112.95}{7.36} = 15.34 \text{ (XX)}$$

XX = Significant at 1% level

Table No.14

Analysis of covariance between Karwar, Bhatkal, Murdeshwar and Mangalore.

HEIGHT OF HEAD ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	7068.16	34990.52	.133623	4674.73	348
Bhatkal	661.40	1652.65	.118592	195.99	113
Murdeshwar	583.65	1029.97	.081459	83.90	122
Mangalore	900.28	4986.63	.121765	607.19	104
	9213.49	43659.77		5561.81	687

bw = .129510 bwSxyw = 5524.85

$$F = \frac{36.96/3}{3651.68/687} = \frac{12.32}{5.31} = 2.32 \text{ (N.S.)}$$

N.S. = Not significant.

Table No.15

Statement showing the results of the analysis of covariance of different morphometric measurements on standard length - All the four places combined.

BODY MEASUREMENTS	SIGNIFICANT/NOT SIGNIFICANT
Total length	Significant at 1% level
Head length	Significant at 1% level
Length upto anus	Not significant
Body length	Significant at 1% level
Maximum body depth along the pectoral fin	Significant at 1% level
Maximum body depth along the anal fin	Significant at 1% level
Depth of caudal peduncle	Signficant at 1% level
Interorbital space	Significant at 1% level
Diameter of the eye	Significant at 1% level
Length of maxillary	Not significant
Length of pectoral	Significant at 1% level
Upper jaw to the dorsal fin	Significant at 1% level
Height of head	Not significant

Analysis of covariance between Bhatkal, Murdeshwar and Mangalore.

The samples from Bhatkal, Murdeshwar and Mangalore were tested together. The results of the analysis of covariance in respect of these samples are given in Table Nos. 16-28 and the summary of the results presented in Table No.29. The regressions of eight characters namely total length, length upto anus, depth of caudal peduncle, interorbital space, length of maxillary, length of pectoral, upper jaw to the dorsal fin and height of head on standard length do not show significant differences at 5% level, while the remaining characters, namely head length, body length, maximum body depth along the pectoral fin, maximum body depth along the anal fin and diameter of the eye show highly significant differences at 1% level. It therefore appears that the samples from Bhatkal, Murdeshwar and Mangalore are closely related to one another. The Karwar samples, on the other hand, when taken into consideration with these, show highly significant differences. This signifies that they do not originate from the same stock.

Table No.16

Analysis of covariance between Bhatkal, Murdeshwar and Mangalore.

TOTAL LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	Sx^2	b	bSxy	d.f
Bhatkal	18826.68	15279.65	13935.59	1.096448	16753.38	113
Murdeshwar	16223.48	13837.73	12644.01	1.094481	15144.12	122
Mangalore	52775.82	45938.42	40953.01	1.121734	51539.38	104
	87825.98	75053.80	67532.61		83436.88	339

bw = 1.111371 bwSxyw = 83412.54

$$F = \frac{24.34/2}{4389.10/339} = \frac{12.17 \times 339}{4389} = .939 \text{ (N.S)}$$

N.S. = Not significant

Table No.17

Analysis of covariance between Bhatkal, Murdeshwar and Mangalore.

HEAD LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	792.84	1469.85	.105475	155.03	113
Murdeshwar	883.91	2761.83	.218430	603.27	122
Mangalore	2517.28	9259.68	.226105	2093.61	104
	4194.03	13491.36		2851.91	339

bw = .199775 bwSxyw = 2695.24

$$F = \frac{156.67/2}{1342.12/339} = \frac{78.33 \times 339}{1342.12} = 19.78 \text{ (XX)}$$

XX = Significant at 1% level

Table No.18

Analysis of covariance between Bhatkal, Murdeshwar and Mangalore.

LENGTH UPTO ANUS ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	5036.40	7506.60	.538664	4043.53	113
Murdeshwar	4670.69	6758.89	.534553	3612.99	122
Mangalore	14190.00	22563.00	.550949	12431.08	104
	23897.09	36828.49		20087.60	339

bw = .545343 bwSxyw = 20084.16

$$F = \frac{3.44/2}{3809.49/339} = \frac{1.72 \times 339}{3809.49} = .153 \text{ (N.S.)}$$

N.S. = Not significant

Table No.19

Analysis of covariance between Bhatkal, Murdeshwar and Mangalore.

BODY LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	8944.19	10829.37	.777101	8415.53	113
Murdeshwar	8402.86	9979.29	.789250	7876.16	122
Mangalore	22936.12	15176.03	.370572	5623.80	104
	40283.16	35984.69		21915.49	339

bw = .532849   bwSxyw = 19174.41

$$F = \frac{2741.08/2}{18367.67/339} = \frac{1370.54 \times 339}{18367.67} = 25.29 \text{ (XX)}$$

XX = Significant at 1% level

Table No.20

Analysis of covariance between Bhatkal, Murdeshwar and Mangalore.

MAXIMUM BODY DEPTH ALONG THE PECTORAL FIN ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	1417.60	3764.80	.270157	1017.09	113
Murdeshwar	1005.11	2839.57	.224578	637.70	122
Mangalore	4246.14	12682.60	.309686	3927.62	104
	6668.85	19286.97		5582.41	339

bw = .285594 bwSxyw = 5508.24

$$F = \frac{74.27/2}{1086.44/339} = \frac{37.13 \times 339}{1086.44} = 11.58 \text{ (XX)}$$

XX = Significant at 1% level

Table No.21

Analysis of covariance between Bhatkal, Murdeshear and Mangalore.

MAXIMUM BODY DEPTH ALONG THE ANAL FIN ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Bhatkal	1242.38	3481.50	.249828	869.78	113
Murdeshwar	802.84	2487.93	.196767	489.54	122
Mangalore	3880.00	12113.00	.295778	3582.75	104
	5925.22	18082.43		4942.07	339

bw = .267758   bwSxyw = 4841.72

$$F = \frac{100.35/2}{983.15/339} = \frac{50.17 \times 339}{983.15} = 17.22 (XX)$$

XX = Significant at 1% level

Table No.22

Analysis of covariance between Bhatkal, Murdeshwar and Mangalore.

DEPTH OF CAUDAL PEDUNCLE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Bhatkal	187.16	988.68	.070946	70.14	113
Murdeshwar	130.37	555.13	.043905	24.37	122
Mangalore	291.43	2636.63	.064382	169.75	104
	608.96	4180.44		264.26	339

bw = .061902 bwSxyw = 258.78

$$F = \frac{5.48/2}{344.70/339} = \frac{2.74 \times 339}{344.70} = 2.69 \text{ (N.S.)}$$

N.S. = Not Significant.

Table No.23

Analysis of covariance between Bhatkal, Murdeshwar and Mangalore.

INTERORBITAL SPACE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	16.66	245.66	.017628	4.33	113
Murdeshwar	47.54	309.89	.024509	7.59	122
Mangalore	46.62	857.03	.020927	17.93	104
	110.82	1412.58		29.85	339

bw = .020917   bwSxy = 29.55

$$F = \frac{.30/2}{80.97/339} = \frac{.15 \times 339}{80.97} = .628 \text{ (N.S.)}$$

N.S. = Not significant

Table No.24

Analysis of covariance between Bhatkal, Murdeshwar and Mangalore.

DIAMETER OF THE EYE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Bhatkal	72.78	173.03	.012416	2.15	113
Murdeshwar	214.79	460.69	.036435	16.79	122
Mangalore	239.87	2634.89	.064338	169.53	104
	527.44	3268.61		188.47	339

bw = .048400   bwSxy = 158.20

$$F = \frac{30.27/2}{338.97/339} = \frac{15.13 \times 339}{338.97} = 15.13 \text{ (XX)}$$

XX = Signficant at 1% level

Table No.25

Analysis of covariance between Bhatkal, Murdeshwar and Mangalore.

DIAMETER OF THE EYE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	72.78	173.03	.012416	2.15	113
Murdeshwar	214.79	460.69	.036435	16.79	122
Mangalore	239.87	2634.89	.064339	169.53	104
	527.44	3268.61		188.47	339

bw = .048400 bwSxy = 158.20

$$F = \frac{30.27/2}{338.97/339} = \frac{15.13 \times 339}{338.97} = 15.13 \text{ (XX)}$$

XX = Significant at 1% level

Table No.26

Analysis of covariance between Bhatkal, Murdeshwar and Mangalore.

LENGTH OF PECTORAL ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	791.66	2538.86	.182185	462.54	113
Murdeshwar	1380.06	2492.44	.197124	491.32	122
Mangalore	3417.45	8916.09	.217715	1941.16	104
	5589.17	13947.39		2895.02	339

bw = .206528 bwSxyw = 2880.53

$$F = \frac{14.49/2}{2694.15/339} = \frac{7.24 \times 339}{2694.15} = .91 \text{(N.S.)}$$

NS. = Not significant

Table No.27

Analysis of covariance between Bhatkal, Murdeshwar and Mangalore.

UPPER JAW TO THE DORSAL FIN ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	6664.91	174775.50	.566026	4464.79	113
Murdeshwar	4477.03	7887.90	.550408	3830.46	122
Mangalore	16533.72	25371.40		15718.19	104
	27675.66	40218.66		24013.44	339

bw = .595544 bwSxyw = 23951.98

$$F = \frac{61.46/2}{3662.22/339} = \frac{30.78 \times 339}{3662.22} = 2.85 \quad (N.S.)$$

N.S. = Not significant

Table No.28

Analysis of covariance between Bhatkal, Murdeshwar and Mangalore.

HEIGHT OF HEAD ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	661.40	1652.65	.118592	195.99	113
Murdeshwar	583.65	1029.97	.081459	83.90	122
Mangalore	900.28	4986.63	.121765	607.19	104
	2145.33	7669.25		887.08	339

bw = .113564 bwSxyw = 870.95

$$F = \frac{16.13/2}{1258.25/339} = \frac{8.06 \times 339}{1258.25} = 2.17 \text{ (N.S.)}$$

N.S. = Not significant

Table No.29

Statement showing the results of the analysis of covariance of different morphometric measurements on standard length - between Bhatkal, Murdeshwar and Mangalore.

BODY MEASUREMENTS	SIGNIFICANT/NOT SIGNIFICANT
Total length	Not significant
Head length	Significant at 1% level
Length upto anus	Not significant
Body length	Significant at 1% level
Maximum body depth along the pectoral fin	Significant at 1% level
Maximum body depth along the anal fin	Significant at 1% level
Depth of caudal peduncle	Not significant
Interorbital space	Not significant
Diameter of the eye	Significant at 1% level
Length of maxillary	Not significant
Length of pectoral	Not significant
Upper jaw to the dorsal fin	Not significant
Height of head	Not significant

Analysis of covariance between Bhatkal and Murdeshwar.

The samples from Bhatkal and Murdeshwar were tested together as the ecological conditions available at these places are more or less similar. The results of the analysis of covariance between the samples from these two places for the thirteen regressions on standard length are given in Table Nos. 30 to 42. The statement showing the results are reproduced in Table No43. From this table it is seen that the regressions of total length, length upto anus, body length, interorbital space, diameter of the eye, length of maxillary, length of pectoral, upper jaw to the dorsal fin and height of head on standard length do not show differences at 5% level, while the regressions of maximum body depth along the pectoral fin and depth of caudal peduncle show differences only at 5% level, but not at 1% level, and those of head length and maximum body depth along the anal fin are significantly different at 1% level. This indicates that both the samples appear to come from closely related stocks, as the regressions of only two characters are significantly different.

Table No. 30

Analysis of covariance between Bhatkal and Murdeshwar.

TOTAL LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	Sx^2	b	bSxy	d.f.
Bhatkal	18826.68	16279.65	13935.59	1.096448	16753.38	113
Murdeshwar	16223.48	13837.73	12644.01	1.094481	15144.12	122
	35050.16	29117.38	26579.60		31897.50	235

$bw = 1.095478 \quad bwSxyw = 31897.49$

$$F = \frac{.01/1}{3152.66/235} = \frac{2.350}{3152} = .0074 \text{ (N.S.)}$$

N.S. = Not significant

Table No.31

Analysis of covariance between Bhatkal and Murdeshwar

HEAD LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	792.84	1469.85	.105475	155.03	113
Murdeshwar	883.91	2761.83	.218430	603.27	122
	1676.75	4231.68		758.30	235

bw = .159208 bwSxyw = 673.72

$$F = \frac{84.58/1}{918.45/235} = \frac{84.58 \times 235}{918.45} = 21.61 \text{ (XX)}$$

XX = Signficant at 1% level

Table No.32

Analysis of covariance between Bhatkal and Murdeshwar

LENGTH UPTO ANUS ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	5036.40	7506.60	.538664	4043.53	113
Murdeshwar	4640.69	6758.89	.5345527	3612.99	122
	9677.09	14265.49		7656.52	235

bw = .536708 bwSxyw = 7656.40

$$F = \frac{.12/1}{2020.57/235} = \frac{235 \times .12}{2020.57} = .013 \text{ (N.S.)}$$

N.S. = Not significant

Table No.33

Analysis of covariance between Bhatkal and Murdeshwar

BODY LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Bhatkal	8944.19	10829.37	.777101	8415.53	113
Murdeshwar	8402.85	9979.29	.789250	7876.16	122
	17347.04	20808.66		16291.69	235

bw = .782881   bwSxyw = 16290.73

$$F = \frac{.96/1}{1055.35/235} = .214 \text{ (N.S.)}$$

N.S. = Not significant

Table No.34

Analysis of covariance between Bhatkal and Murdeshwar

MAXIMUM BODY DEPTH ALONG THE PECTORAL FIN ON STANDARD LENGTH.

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	1417.60	3764.80	.270157	1017.09	113
Murdeshwar	1005.11	2839.57	.224578	637.70	122
	2422.71	6604.37		1654.79	235

bw = .248475 bwSxyw = 1641.02

$$F = \frac{13.77/1}{767.92/235} = 4.22 \ (X)$$

X = Significant at 5% level

Table No.35

Analysis of covariance between Bhatkal and Murdeshwar

MAXIMUM BODY DEPTH ALONG THE ANAL FIN ON STANDARD LENGTH.

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	1242.38	3481.50	.249828	897.78	113
Murdeshwar	802.84	2487.93	.196767	498.54	122
	2045.22	5969.43		1396.32	235

bw = .224587 bwSxyw = 1340.66

$$F = \frac{55.66/1}{648.90/235} = 20.10 \text{ (XX)}$$

XX = Significant at 1% level

Table No.36

Analysis of covariance between Bhatkal and Murdeshwar

DEPTH OF CAUDAL PEDUNCLE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Bhatkal	187.16	988.68	.070946	70.14	113
Murdeshwar	130.36	555.13	.043905	24.37	122
	317.52	1543.81		94.51	235

bw = .058083   bwSxy = 89.67

$$F = \frac{4.84/1}{223.01/235} = 5.13(X)$$

X = Significant at 5% level

Table No.37

Analysis of covariance between Bhatkal and Murdeshwar

INTERORBITAL SPACE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Bhatkal	16.66	245.66	.017628	4.33	113
Murdeshwar	47.54	309.89	.024509	7.59	122
	64.20	555.55		11.92	235

bw = .020902 bwSxy = 11.61

$$F = \frac{.31/1}{52.28/235} = 1.52 \text{(N.S.)}$$

N.S = Not significant

Table No.38

Analysis of covariance between Bhatkal and Murdeshwar

DIAMETER OF THE EYE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Bhatkal	72.78	173.03	.012416	2.15	113
Murdeshwar	214.79	460.69	.036435	16.79	122
	287.57	633.72		18.94	235

bw = .023842 bwSxyw = 15.10

$$F = \frac{3.84/1}{268.63/235} = 3.36 \text{ (N.S.)}$$

N.S = Not significant

Table No.39

Analysis of covariance between Bhatkal and Murdeshwar

LENGTH OF MAXILLARY ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Bhatkal	238.17	1489.45	.106881	159.19	113
Murdeshwar	225.76	1324.31	.104738	138.71	122
	463.93	2813.76		297.90	235

bw = .105862 bwSxyw = 297.37

$$F = \frac{.53/1}{166.03/235} = .753 \text{ (N.S.)}$$

N.S = Not significant

Table No.40

Analysis of covariance between Bhatkal and Murdeshwar

LENGTH OF PECTORAL ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Bhatkal	791.66	2538.86	.182185	462.54	113
Murdeshwar	1380.06	2492.44	.197124	491.32	122
	2171.72	5031.30		953.86	235

$bw = .189292 \quad bwSxyw = 952.38$

$$F = \frac{1.48/1}{1217.86/235} = .285 \text{ (N.S.)}$$

N.S. = Not significant

Table No.41

Analysis of covariance between Bhatkal and Murdeshwar.

UPPER JAW TO DORSAL FIN ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Bhatkal	6664.91	7887.90	.566026	4464.79	113
Murdeshwar	4477.03	6959.36	.550408	3830.46	122
	11141.94	14847.26		8295.25	235

$bw = .558596$ $\quad bwSxyw = 8293.62$

$$F = \frac{1.63/1}{2846.69/235} = .135 \text{(N.S.)}$$

N.S = Not significant.

Table No.42

Analysis of covariance between Bhatkal and Murdeshwar

HEIGHT OF HEAD ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Bhatkal	661.40	1652.65	.118592	195.99	113
Murdeshwar	583.65	1029.97	.081459	83.90	122
	1245.05	2682.62		279.89	235

bw = .100928   bwSxyw = 270.75

$$F = \frac{9.14/1}{965.16/235} = 2.22(\text{N.S.})$$

N.S = Not significant

Table No.43

Statement showing the results of the analysis of covariance of different morphometric measurements on standard length - Bhatkal and Murdeshwar

BODY MEASUREMENTS	SIGNIFICANT/NOT SIGNIFICANT
Total length	Not significant
Head length	Significant at 1% level
Length upto anus	Not significant
Body length	Not significant
Maximum body depth along the pectoral fin	Significant at 5% level
Maximum body depth along the anal fin	Significant at 1% level
Depth of caudal peduncle	Significant at 5% level
Interorbital space	Not significant
Eye diameter	Not significant
Length of maxillary	Not significant
Length of pectoral	Not significant
Upper jaw to dorsal fin	Not significant
Height of head	Not significant

Analysis of covariance between Karwar and Bhatkal

Table Nos. 44 to 56 gave the results of the analysis of covariance where the samples from Bhatkal and Karwar are compared. The statement showing the results of this analysis are given in Table No.57. The regressions of seven characters namely total length, head length, body length, maximum body depth along the anal fin, diameter of the eye, length of pectoral and upper jaw to dorsal fin on standard length show highly significant differences at 1% level, while those of depth of caudal peduncle and interorbital space showed differences at 5% level. The regressions of length upto anus, maximum body depth along the pectoral fin, length of maxillary and height of head on standard length are not significantly different at 5% level. In view of this and of the results of the analysis between all the samples from the coast, it appears that the samples from these two centres come from widely different stocks.

Table No.44

Analysis of covariance between Karwar and Bhatkal.

TOTAL LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	Sx^2	b	bSxy	d.f
Karwar	404986.64	324010.96	261859.31	1.23734	400914.89	348
Bhatkal	18826.68	15279.65	13935.59	1.096448	16753.38	113
	423813.32	339290.61	275794.90		417668.27	461

bw = 1.230228 bwSxyw = 417405.47

$$F = \frac{262.80}{6145.05/461} = \frac{262.80}{13.33} = 19.71 \text{ (XX)}$$

XX = Significant at 1% level

Table No.45

Analysis of covariance between Karwar and Bhatkal

HEAD LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	13242.83	57614.56	.220021	12676.36	348
Bhatkal	792.84	1469.85	.105475	155.03	113
	14035.67	59084.41		12831.39	461

$$bw = .214233 \qquad bwSxyw = 12657.83$$

$$F = \frac{173.56}{1204.28/461} = \frac{173.56}{2.61} = 66.48 \text{ (XX)}$$

XX = Significant at 1% level

Table No.46

Analysis of covariance between Karwar and Bhatkal.

LENGTH UPTO ANUS ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Karwar	85660.57	148693.17	.567830	84432.35	348
Bhatkal	5036.40	7506.60	.538664	4043.53	113
	90696.97	156199.77		88475.88	461

bw = .566362 bwSxyw = 88465.63

$$F = \frac{10.25}{2221.09/461} = \frac{10.25}{4.82} = 2.13 \text{ (N.S.)}$$

N.S = Not significant

Table No.47

Analysis of covariance between Karwar and Bhatkal

BODY LENGTH ON STANDARD LENGTH.

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	178238.24	215915.38	.824540	178030.58	348
Bhatkal	8944.19	10829.37	.777101	8415.53	113
	187182.43	226744.75		186446.11	461

bw = .822149   bwSxyw = 186417.93

$$F = \frac{28.18}{736.32/461} = \frac{28.18}{1.60} = 17.61\ (XX)$$

XX = Significant at 1% level

Table No.48

Analysis of covariance between Karwar and Bhatkal

MAXIMUM BODY DEPTH ALONG THE PECTORAL FIN ON STANDARD LENGTH.

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	26428.79	79411.76	.303261	24082.41	348
Bhatkal	1417.60	3764.80	.270157	1017.09	113
	27846.39	83176.56		25099.50	461

bw = .301588 bwSxyw = 25085.05

$$F = \frac{14.45}{2746.89/461} = \frac{14.45}{5.96} = 2.42 \text{ (N.S.)}$$

N.S = Not significant

Table No.49

Analysis of covariance between Karwar and Bhatkal

MAXIMUM BODY DEPTH ALONG THE ANAL FIN ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Karwar	27262.64	83405.40	.318512	26565.62	348
Bhatkal	1242.38	3481.50	.249828	869.78	113
	28505.02	86886.90		27435.40	461

bw = .315042 bwSxyw = 27373.02

$$F = \frac{62.38}{1069.62/461} = \frac{62.38}{2.32} = 26.88 \text{ (XX)}$$

XX = Significant at 1% level

Table No.50

Analysis of covariance between Karwar and Bhatkal

DEPTH OF CAUDAL PEDUNCLE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	2105.74	22340.39	.085314	1905.94	348
Bhatkal	187.16	988.68	.070946	70.14	113
	2292.90	23329.07		1976.08	461

bw = .084588 bwSxyw = 1973.36

$$F = \frac{2.72}{319.52/461} = \frac{2.72}{.69} = 3.94\ (X)$$

X = Significant at 5% level

Table No.51

Analysis of covariance between Karwar and Bhatkal

INTERORBITAL SPACE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	641.25	9138.90	.034901	318.96	348
Bhatkal	16.66	245.66	.017628	4.33	113
	657.91	9384.56		323.29	461

bw = .034027 bwSxyw = 319.32

$$F = \frac{3.97}{334.62/461} = \frac{3.97}{.73} = 5.44(X)$$

X = Significant at 5% level

Table No.52

Analysis of covariance between Karwar and Bhatkal

EYE DIAMETER ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	1248.40	15673.77	.059855	938.15	348
Bhatkal	72.78	173.03	.012416	2.15	113
	1321.18	15846.80		940.30	461

bw = .057459   bwSxyw = 910.54

$$F = \frac{29.76}{380.88/461} = \frac{29.76}{.83} = 35.85 \text{ (XX)}$$

XX = Significant at 1% level

Table No.53

Analysis of covariance between Karwar and Bhatkal

LENGTH OF MAXILLARY ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Karwar	3945.24	30422.05	.116177	3534.34	348
Bhatkal	238.17	1489.45	.106881	159.19	113
	4183.41	31911.50		3693.53	461

bw = .115707 bwSxyw = 3692.38

$$F = \frac{1.15}{489.88/461} = \frac{1.15}{1.06} = 1.08 \text{ (N.S.)}$$

N.S = Not significant

Table No.54

Analysis of covariance between Karwar and Bhatkal

LENGTH OF PECTORAL ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Karwar	15605.46	62915.21	.240263	15116.20	348
Bhatkal	791.66	2538.86	.182185	462.54	113
	16397.12	65454.07		15578.74	461

bw = .237331   bwSxyw = 15534.28

$$F = \frac{44.46}{818.38/461} = \frac{44.46}{1.78} = 24.98 \text{ (XX)}$$

XX = Significant at 1% level

Table No.55

Analysis of covariance between Karwar and Bhatkal

UPPER JAW TO THE DORSAL FIN ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Karwar	118048.50	174775.50	.667441	116652.00	348
Bhatkal	6664.91	7887.90	.566026	4464.79	113
	124713.41	182663.40		121116.79	461

bw = .662316 bwSxyw = 120980.89

$$F = \frac{135.90}{3596.62/461} = \frac{135.90}{7.80} = 17.42 \text{ (XX)}$$

XX = Significant at 1% level

Table No.56

Analysis of covariance between Karwar and Bhatkal

HEIGHT OF HEAD ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f.
Karwar	7068.16	34990.52	.133623	4674.73	348
Bhatkal	661.40	1652.65	.118592	195.99	113
	7729.56	36643.17		4870.72	461

bw = .132864 bwSxyw = 4868.56

$$F = \frac{2.16}{2858.84/461} = \frac{2.16}{6.2} = .34 \text{ (N.S.)}$$

N.S = Not significant

Table No. 57

Statement showing the results of the analysis of covariance of different morphometric measurements on standard length - between Karwar and Bhatkal.

BODY MEASUREMENTS	SIGNIFICANT/NOT SIGNIFICANT
Total length	Significant at 1% level
Head length	Significant at 1% level
Length upto anus	Not significant
Body length	Significant at 1% level
Maximum body depth along the pectoral fin	Not significant
Maximum body depth along the anal fin	Significant at 1% level
Depth of caudal peduncle	Significant at 5% level
Interorbital space	Significant at 5% level
Diameter of the eye	Significant at 1% level
Length of maxillary	Not significant
Length of pectoral	Significant at 1% level
Upper jaw to the dorsal fin	Significant at 1% level
Height of head	Not significant

Analysis of covariance between Karwar and Mangalore.

The results of the analysis of covariance between the samples from Karwar and Mangalore are shown in Table Nos. 58 to 70 and the statement showing the results are reproduced in Table No.71.

The regressions of six characters namely total length, body length, maximum body depth along the anal fin, depth of caudal peduncle, interorbital space and upper jaw to the dorsal fin on standard length are significantly different at 1% level, and one character viz. length of pectoral at 5% level. It can therefore be concluded that the stocks at these two places are quite independent of one another.

Table No.58

Analysis of covariance between Karwar and Mangalore.

TOTAL LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	Sx^2	b	bSxy	d.f
Karwar	404986.64	324010.96	261859.31	1.237340	400914.89	348
Mangalore	52775.82	45938.42	40953.01	1.121734	51539.38	104
	457762.46	369949.38	302812.32		452454.27	452

bw = 1.221711   bwSxyw = 451970.76

$$F = \frac{483.51/1}{5308.19/452} = 41.17 \text{ (XX)}$$

XX = Significant at 1% level

Table No.59

Analysis of covariance between Karwar and Mangalore

HEAD LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	13242.83	57614.56	.220021	12676.36	348
Mangalore	2517.28	9259.68	.226105	2093.61	104
	15760.11	66874.24		14769.97	452

$bw = .220843 \qquad bwSxyw = 14768.71$

$$F = \frac{1.26/1}{990.14/452} = .57 \text{ (N.S.)}$$

Table No.60

Analysis of covariance between Karwar and Mangalore

LENGTH UPTO ANUS ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	85660.57	148693.17	.567830	84432.35	348
Mangalore	14190.00	22563.00	.550949	12431.08	104
	99850.57	171256.17		96863.43	452

$bw = .56552 \quad bwSxyw = 96854.29$

$$F = \frac{9.14/1}{2987.14/452} = 1.38 \text{ (N.S.)}$$

N.S = Not significant

Table No.61

Analysis of covariance between Karwar and Mangalore.

BODY LENGTH ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	178238.24	215915.38	.824540	178030.88	348
Mangalore	22936.12	15176.03	.370572	5623.80	104
	201174.36	231091.41		183654.68	452

bw = .763156 bwSxyw = 176358.48

$$F = \frac{7296.20/1}{17519.68/452} = 188.2 \text{ (XX)}$$

XX = Significant at 1% level

Table No.62

Analysis of covariance between Karwar and Mangalore

MAXIMUM BODY DEPTH ALONG THE PECTORAL FIN ON STANDARD LENGTH.

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	26428.79	79411.76	.30326	24082.41	348
Mangalore	4246.14	12682.60	.309686	3927.62	104
	30674.93	92094.36		28010.03	452

bw = .304130   bwSxyw = 28008.65

$$F = \frac{1.37/1}{2664.90/452} = .23(\text{N.S.})$$

N.S = Not significant

Table No.63

Analysis of covariance between Karwar and Mangalore.

MAXIMUM BODY DEPTH ALONG THE ANAL FIN ON STANDARD LENGTH.

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	27262.64	83405.40	.318512	26565.62	348
Mangalore	3880.00	12113.00	.295778	3582.75	104
	31142.64	95518.40		30148.37	452

$bw = .315437$ $\quad bwSxyw = 30130.04$

$$F = \frac{18.34/1}{994.26/452} = 8.35 \text{ (XX)}$$

XX = Significant at 1% level

Table No.64

Analysis of covariance between Karwar and Mangalore.

DEPTH OF CAUDAL PEDUNCLE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	2105.74	22340.39	.085314	1905.94	348
Mangalore	291.43	2636.63	.0643818	169.75	104
	2397.17	24977.02		2075.69	452

bw = .082484   bwSxyw = 2060.20

$$F = \frac{15.49/1}{321.48/452} = 21.77 \text{ (XX)}$$

XX = Significant at 1% level

Table No.65

Analysis of covariance between Karwar and Mangalore

INTERORBITAL SPACE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	641.25	9138.90	.034901	318.96	348
Mangalore	46.62	857.03	.020927	17.93	104
	687.87	9995.93		336.89	452

bw = .033010 bwSxyw = 329.97

$$F = \frac{6.92/1}{350.98/452} = 8.91 \text{ (XX)}$$

XX = Significant at 1% level

Table No.66

Analysis of covariance between Karwar and Mangalore.

DIAMETER OF THE EYE ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	1248.40	15673.77	.059855	983.15	348
Mangalore	239.87	2634.89	.064339	169.53	104
	1488.27	18308.66		1107.68	452

$bw = .060463 \qquad bwSxyw = 1107.00$

$$F = \frac{.68/1}{380.59/452} = .807 \text{ (N.S.)}$$

N.S = Not significant

Table No.67

Analysis of covariance between Karwar and Mangalore.

LENGTH OF MAXILLARY ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	3945.24	30422.05	.116177	3534.34	348
Mangalore	803.65	4782.10	.116770	558.41	104
	4748.89	35204.15		4092.75	452

bw = .116257 bwSxyw = 4092.73

$$F = \frac{.02/1}{656.14/452} = .013 \text{ (N.S.)}$$

N.S = Not significant

Table No.68

Analysis of covariance between Karwar and Mangalore.

LENGTH OF PECTORAL ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	15605.46	62915.21	.240263	15116.20	348
Mangalore	3417.45	8916.09	.217715	1941.16	104
	19022.91	71831.30		17057.36	452

bw = .237214 bwSxyw = 17039.39

$$F = \frac{17.97/1}{1955.75/452} = 4.15 \ (X)$$

X = Signficant at 5% level

Table No.69

Analysis of covariance between Karwar and Mangalore.

UPPER JAW TO THE DORSAL FIN ON STANDARD LENGTH

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	118048.50	17475.50	.667441	116652.00	348
Mangalore	16533.72	25371.40	.619524	15718.19	104
	134582.22	42846.90		132370.19	452

bw = .660962 bwSxyw = 132289.50

$$F = \frac{80.69/1}{2212.03/452} = 16.48 \text{ (XX)}$$

XX = Significant at 1% level

Table No.70

Analysis of covariance between Karwar and Mangalore.

HEIGHT OF HEAD ON STANDARD LENGTH.

Places	Sy^2	Sxy	b	bSxy	d.f
Karwar	7068.16	34990.52	.133623	4674.73	348
Mangalore	900.28	4986.63	.121765	607.19	104
	7968.44	39977.15		5281.92	452

bw = .132020 bwSxyw = 5277.78

$$F = \frac{4.14/1}{2686.52/452} = .69 \text{ (N.S.)}$$

N.S = Not significant

Table No.71

Statement showing the results of the analysis of covariance of different morphometric measurements on standard length - Between Karwar and Mangalore.

BODY MEASUREMENTS	SIGNIFICANT/NOT SIGNIFICANT
Total length	Significant at 1% level
Head length	Not significant
Length upto anus	Not significant
Body length	Significant at 1% level
Maximum body depth along the pectoral fin	Not significant
Maximum body depth along the anal fin	Significant at 1% level
Depth of caudal peduncle	Significant at 1% level
Interorbital space	Significant at 1% level
Diameter of the eye	Not significant
Length of maxillary	Not significant
Length of pectoral	Significant at 5% level
Upper jaw to the dorsal fin	Significant at 1% level
Height of head	Not significant

Discussion

Table No.72 gives a summary of the results of the analysis of covariance in respect of regressions of morphometric measurements on standard length. The regressions of length upto anus, length of maxillary and height of head are not significant throughout. It therefore appears that these characters do not vary with changes in the ecological conditions and hence are not likely to be useful in delimitation of the stocks. It is also seen that the regression in maximum body depth along the anal fin on standard length vary significantly in all the comparisons indicating that this character is easily affected by even slight changes in the ecological conditions and hence may not be very helpful in studies on delimitation of stocks. Therefore, the results of analysis of these characters have been ignored in the present study.

The results of the analysis of covariance in respect of all the localities show that all the nine regressions on standard length are highly significant at 1% level. Therefore, it appears that the catches of <u>Opisthopterus tardoore</u> at these places belong to more than one stock. Covariance analysis between Bhatkal, Murdeshwar and Mangalore showed that out of nine, four characters namely head length, body length, maximum body depth along the pectoral fin and diameter of the eye on standard length

TABLE NO.72

SUMMARY OF THE RESULTS OF REGRESSION OF MORPHOMETRIC MEASUREMENTS ON STANDARD LENGTH BETWEEN PLACES

BETWEEN DIFFERENT LOCALITIES	TOTAL LENGTH	HEAD LENGTH	LENGTH UPTO ANUS	BODY LENGTH	MAXIMUM BODY LENGTH ALONG THE PECTORAL FIN	MAXIMUM BODY DEPTH ALONG THE ANAL FIN	DEPTH OF CAUDAL PEDUNCLE	INTER ORBITAL SPACE	DIAMETER OF THE EYE	LENGTH OF MAXILLARY	LENGTH OF PECTORAL	UPPER JAW TO THE DORSAL FIN	HEIGHT OF HEAD
All the four places	XX	XX	NS	XX	XX	XX	XX	XX	XX	NS	XX	XX	NS
Bhatkal, Murdeshwar and Mangalore.	NS	XX	NS	XX	XX	XX	NS	NS	XX	NS	NS	NS	NS
Bhatkal-Murdeshwar	NS	XX	NS	NS	X	XX	X	NS	NS	NS	NS	NS	NS
Karwar-Bhatkal	XX	XX	NS	XX	NS	XX	X	X	XX	NS	XX	XX	NS
Karwar-Mangalore	XX	NS	NS	XX	NS	XX	XX	XX	NS	NS	X	XX	NS

XX = Significant at 1% level; X = Significant at 5% level; NS = Not significant.

showed significant differences at 1% level. This suggests that the samples come from stocks which are moreor less identical among themselves. Bhatkal and Murdeshwar data were analysed for covariance test and it is seen that only the regression of one character viz. head length on standard length showed highly significant difference at 1% level and two characters i.e. maximum body depth along the pectoral fin and depth of caudal peduncle at 5% level indicating that they are likely to come from a single stock or from a closely related stock. Furthermore the covariance test between Karwar and Bhatkal showed significant differences in the regressions on standard length for six characters namely total length, head length, body length, diameter of the eye, length of pectoral and upper jaw to the dorsal fin at 1% level and two characters viz. depth of caudal peduncle and interorbital space at 5% level. This indicates that the stocks of Bhatkal-Murdeshwar and Karwar are independent of each other. Data for Karwar and Mangalore were analysed separately. It is seen that the regressions on standard length of five characters i.e. total length, body length, depth of caudal peduncle, interorbital space and upper jaw to the dorsal fin are significant at = 1% level. These clearly showed that the two samples are quite independent of one another.

Therefore, the results which are based on the analysis of covariance of nine regressions on standard length, provide sufficient evidence to prove that along the entire Kanara coast, Opisthopterus tardoore fishery is not supported by a common stock. It appears that the samples from Bhatkal-Murdeshwar are either derived from a single stock or from closely related stocks. Mangalore stock is more allied to Bhatkal-Murdeshwar and the Karwar stock is quite independent of the rest.

3. Description of the ovary

The female reproductive organ of *Opisthopterus tardoore* consists of a bilobed ovary. The two lobes of the ovary are asymmetrical both in length and in girth. Such an asymmetrical arrangement of the ovary has been described by Hefford (1910) in the case of *Conger* sp. The right lobe of the ovary measures two thirds of the length of the left lobe, whereas the left one is considerably enlarged (Text Figure 9.) . The latter forms the bulk of the entire organ. Both the lobes are free at the anterior portion. They fuse together in the middle and open to the exterior by a common genital aperture. The mature ovary is generally flattened and packed with large number of ova. It undergoes several changes in its general appearance, size and colour during maturation.

The two different lobes of the testis are also unequal in length and the left lobe is more enlarged than the right (Text Figure 9).

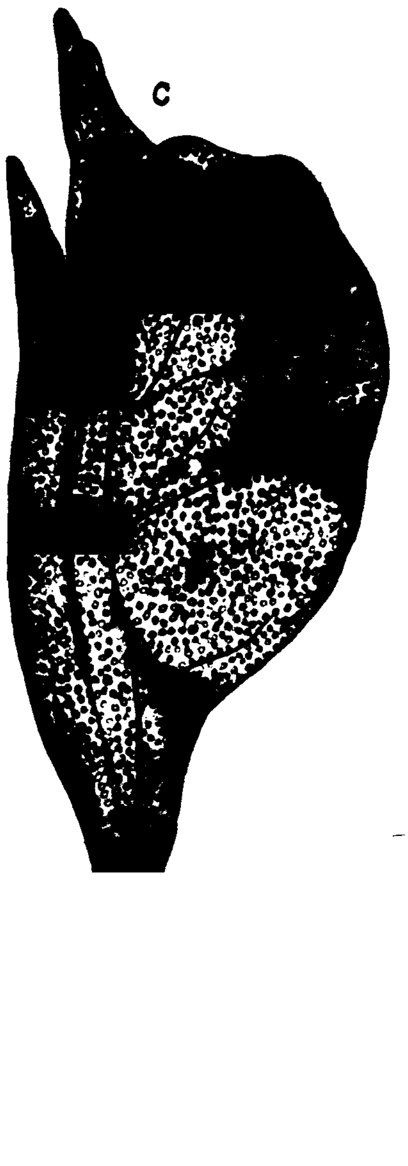
Text-Figure 9.

Asymmetrical lobes of the ovary of *Opisthopterus tardoore* (Cuvier) measuring 142 mm.

The lobes of the testis of *Opisthopterus tardoore* (Cuvier) measuring 149 mm.

B - Right lobe

C - Left lobe


C
B


C
B

4. Stages of maturity

In the present work, five different stages of maturity (Qasim 1956 & 1957) have been recognised, as against seven stages described by the International Council for the exploration of the sea (Hjort 1911). The terms adopted in connection with maturity are immature virgins, maturing virgins or recovered spents, ripening, ripe and spent. The five stages have been described below:

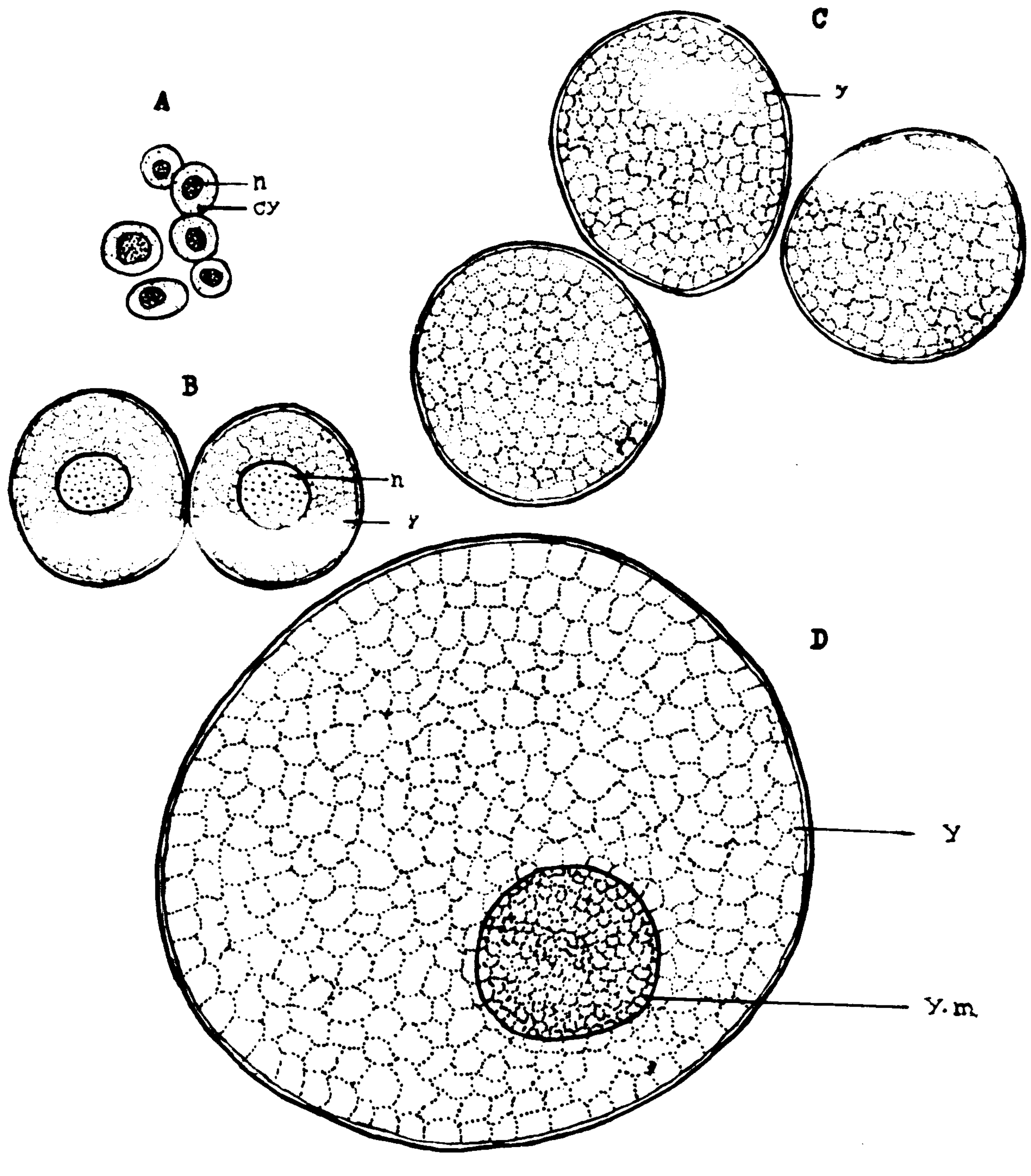
STAGE I	Immature virgins:	Ovaries thin and ribbon like. Eggs microscopic.
STAGE II	Maturing virgins: or Recovered spents:	Ovaries slightly swollen occupying half the body cavity and containing eggs just visible to the naked eye.
STAGE III	Ripening:	Ovaries enlarged and occupying almost three quarters of the length of the body cavity. Conspicuous opaque eggs.
STAGE IV	Ripe	Ovaries very much distended and occupying almost the whole of the body cavity and containing large transparent eggs.
STAGE V	Spent:	Ovaries shrunken and containing residual eggs.

The immature ovary (Stage I) contains microscopic ova which are spherical in shape and each has a large central nucleus surrounded by cytoplasm. The size of the immature ova varies between 0.017 mm. to 0.170 mm. In the II stage of maturity, ova could be easily seen by the naked eye, size range being 0.187 mm. to 0.272 mm. In the ripening stage (Stage III) the size range of the ova varied from 0.289 mm. to 0.748 mm. In these eggs, the yolk completely fills the ovum so that the nucleus is not visible. The ova are more or less round in shape. In the ripe ovary (Stage IV) large transparent ova are easily visible to the naked eye. The diameter of the ova and the yolk mass varies between 0.765 mm. to 0.986 mm. and 0.255 mm. to 0.306 mm. respectively. Spent ovary (Stage V) is blood shot, looks flaccid and wrinkled. It gives the impression of an empty sac. When examined under a microscope a large number of immature ova are seen in it, in addition to a few opaque ones. The latter are likely to be resorbed as they lose their shape and become loosely spread. The various developmental stages of ova of Opisthopterus tardoore are shown in Text Figure 10.

Lack of males in the samples made the author to confine his attention on females only. The other reason of not including males in the observation was due to the fact that the stages of maturity were far less defined.

Text-Figure 10. Developmental stages of ova of
Opisthopterus tardoore (Cuvier)
A Stage I, B Stage II, C Stage III
and D Stage IV.

n: nucleus
cy: cytoplasm
ym: yolk mass
y: yolk


A
n
cy
B
n
y
C
y
D
Y
Y.m

5. Minimum size at maturity

To determine the size at which *Opisthopterus tardoore* matures, the condition of the gonads of 830 specimens ~~were~~ was studied. Table No.73 shows the distribution of these specimens of different size groups according to the condition of the gonads. It can be seen from the Table that about 17.24% of the specimens of 140-149 mm. were in stage III; 48.43% of 150-159 mm; 77.21% of 160-169 mm. size groups and 100% of 170-179 mm. and above. No ripening specimens were noticed among the size groups below 130-139 mm. Since about 50 to 78% were ripening between 150-169 mm. groups, it can be concluded that the first maturity is attained when the fish grows to a length of 150-169 mm. The occurrence of spent gonads at this size range confirms the onset of maturity.

Table No.73

The number of mature females and the percentage of ripening fish in each 10 mm. length.

Size groups (mm)	Total fish observed	Number mature	Percentage mature
60- 69	22	...	...
70- 79	30	...	...
80- 89	30	...	...
90- 99	102	...	...
100-109	98	...	...
110-119	52	...	...
120-129	54	...	...
130-139	58	...	...
140-149	58	10	17.24
150-159	64	31	48.43
160-169	79	61	77.21
170-179	73	73	100.00
180-189	52	52	100.00
190-199	35	35	100.00
200-209	23	23	100.00

6. Sex ratio

A knowledge of the sex composition of catches is of help in understanding whether any differential fishing exists and if so, what possible bearing it has on the fish stocks.

Sexes of this fish could not be determined externally as there was no such characters. In specimens below 100 mm. in total length, a microscopic examination of the gonad was found necessary to distinguish the sex. The data analysed reveal that the two sexes were not occurring in about the same proportion. In many samples the females were found to be more numerous than the males - their proportion ranging from 70-80%. Sex distribution in the monthly samples of Opisthopterus tardoore obtained during 1960 is shown in Table No.74. It can be seen from the Table that from February to July many samples consisted entirely of females and that in all the months, the females dominated the catches. The lack of males in the samples examined may probably be due to the fact that males move on to the spawning grounds in advance of females. It is now well known (Kyle 1926) that males of many species mature earlier than females. Qasim (1956) while working on the biology of Blennius pholis L. has indicated that "the males of this species not only mature earlier than females but continue in a ripe stage as late as September, when spawning in the female is virtually over. This prolonged ripeness in males may be a provision to effect fertilization of as many eggs as possible as suggested by Graham (1924) in Cod." Though no conclusive evidence could be obtained from the present observations, it seems likely to suggest that the availability of less number of males in the catches may be due to their early maturity which may lead to their segregation from the females. This seems associated with their migration towards the spawning ground earlier than the females. The selection of spawning sites seems mainly done by the males of this species.

Table No.74

Sex distribution in the monthly totals of samples of Opisthopterus tardoore examined during 1960. All figures mentioned below are in percentages:

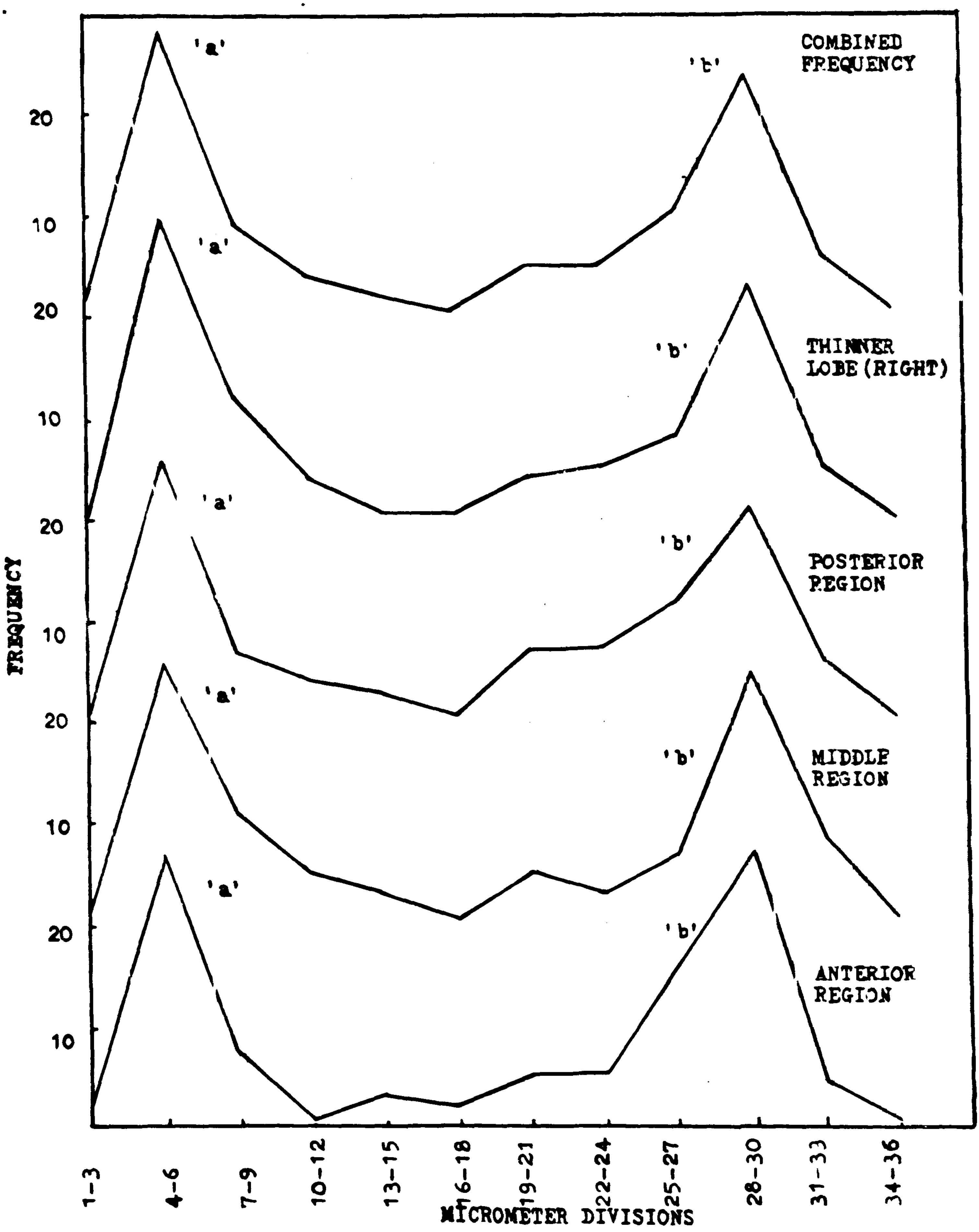
MONTHS	FEMALE	MALE
February	96.9	3.3
March	100.0	...
April	81.5	18.5
May	75.4	24.6
June	92.7	7.3
July	79.2	20.8
August	61.1	28.8

7. Spawning periodicity

To find out whether there was any apparent difference in the distribution of eggs either in different regions (anterior, middle and posterior) of the same lobe or in the two lobes of the ovary of the same fish, measurements of ova were taken from the ovaries of a fish measuring 174 mm. in total length. These have been illustrated in Text Figure 11. It is seen from the figure, that there is no significant difference in the relative numbers of the ova of different size groups in various regions of the ovary. However, to obviate any possibility of error, samples were taken from different regions of both the ovaries and in this manner about 300 eggs were measured from each ovary.

Frequency polygons of the diameters of about 1300 ova obtained from ovaries of three different specimens measuring 163 mm., 167 mm. and 180 mm. in total lengths are shown in Text Figure 12. All these fishes were in stage III (Ripening) of the maturity scale. The size of the ova and the formation of the yolk were relied upon for judging the state of maturity of the intra-ovarian eggs. From the figure it is seen that mode 'b' represents the batch of ova that will ripen and be spawned in the ensuing spawning season. Besides this mode, there is another peak 'a' formed by the immature ova which are transparent and have distinct nuclei and protoplasmic layers. As the batch of ova represented by a clearly

Text-Figure 11. Frequency polygons of the diameters of 1216 ova measured from a mature long finned herring, 174 mm. in total length taken on 31.3.1960 at Karwar.



FREQUENCY
20
10
'a'
'b'
COMBINED FREQUENCY
THINNER LOBE (RIGHT)
POSTERIOR REGION
MIDDLE REGION
ANTERIOR REGION
1–3
4–6
7–9
10–12
13–15
16–18
19–21
22–24
25–27
28–30
31–33
34–36
MICROMETER DIVISIONS

defined mode 'b' is sharply separated from the rest of the stock of eggs, it seems that the spawning in this species is strictly periodic and restricted to a definite period. The absence of multiple modal curves and the presence of only two widely separated groups of eggs indicate that each individual spawns only once in a year. That the small maturing ova included in mode 'a' will ripen and be spawned in the same season seems unlikely.

Walford (1932) states that in fishes which spawn only once in a season their mature ovaries contain only two types of ova, the immature and the mature. Hickling and Rutenberg (1936) remarked "in the ovary of the adult fish there is a general egg stock of small eggs. From this egg stock, a quota is withdrawn each year to be matured and finally spawned and to this egg stock a fresh batch is added every year by the development of oocytes, the minimum period of development being two seasons. It has occurred to us that measurement of the diameters of the eggs in ovaries well advanced towards spawning may give evidence of the duration of spawning in fish of which the spawning habits are unknown." Prabhu (1956) concluded that "in the ovaries of fishes which spawn only once a year and in which the duration of spawning is restricted to a definite and short period, the mature stock of ova will be found to have differentiated from the general egg stock and in the whole ovary there will be only one batch of mature eggs to be shed during the succeeding spawning season". Bearing in mind the suggestions of these and many other workers, the data on the ova diameter measurements of *Opisthopterus tardoore*, conclusively show that the individuals of this species spawn only once a year.

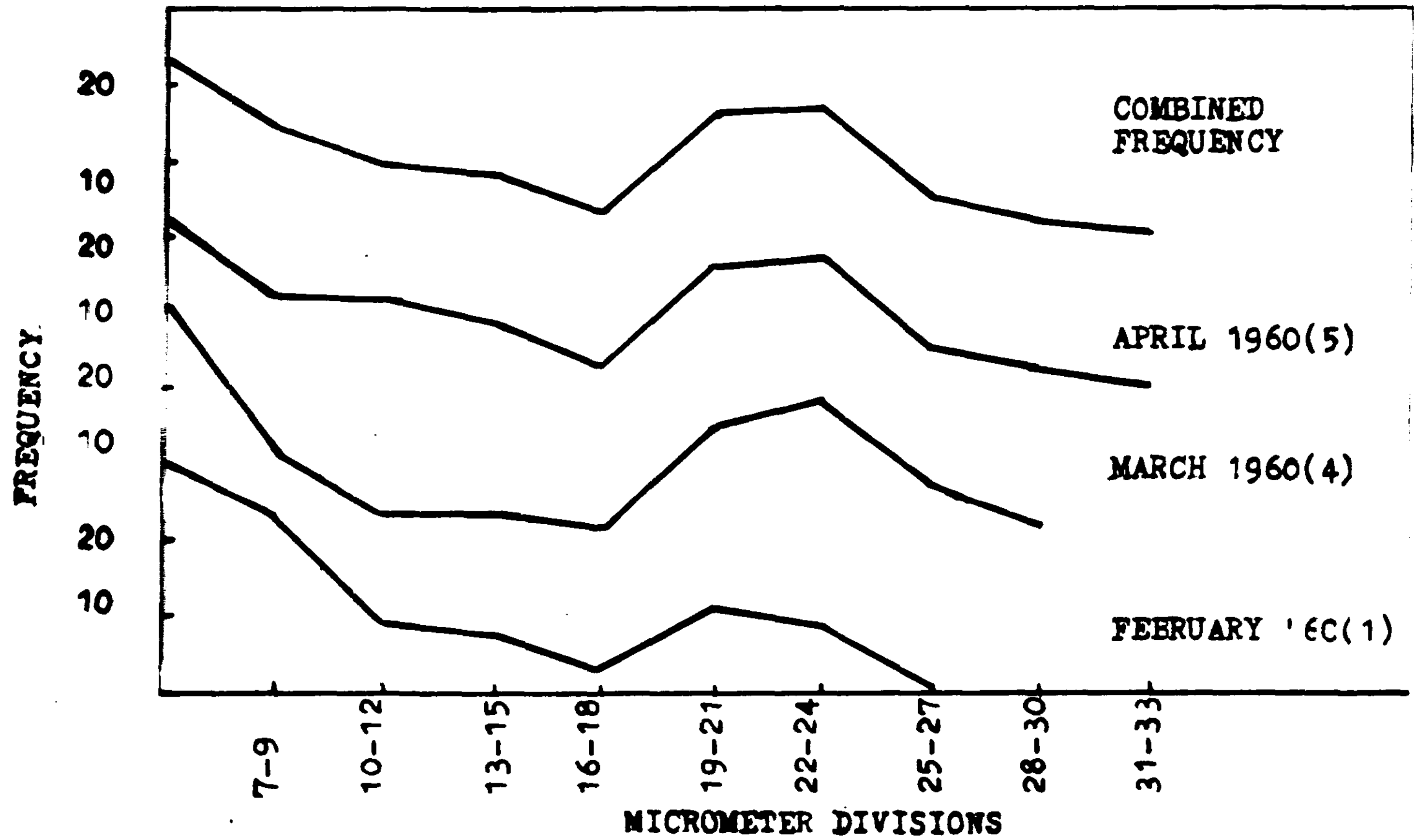
In any species, the maturation of ova and their final withdrawal from the ovary could be traced, if all individuals mature at the same time. But since the stages of maturity vary among individuals of the population, to follow the growth of ova becomes difficult. However, in the present investigation, the location of the largest mode in the diameter frequency of the eggs was taken as a criterion, to illustrate the growth of the maturing eggs from the immature ones.

The ova size frequency curve of a fish with ovaries in the very early stage of maturation showed only a single peak, comprising of immature eggs ranging in diameter upto about 0.170 mm. In the next stage a maturing group is seen at 0.170 mm. to 0.306 mm. This gives an indication that the seperation of this batch of eggs from the general egg stock has been caused due to maturation. In the III stage of maturity, as this batch develops further, (Text Figure 13) the peak is noticed at 0.323 mm. to 0.408 mm., the size range being 0.272 mm. to 0.561 mm.

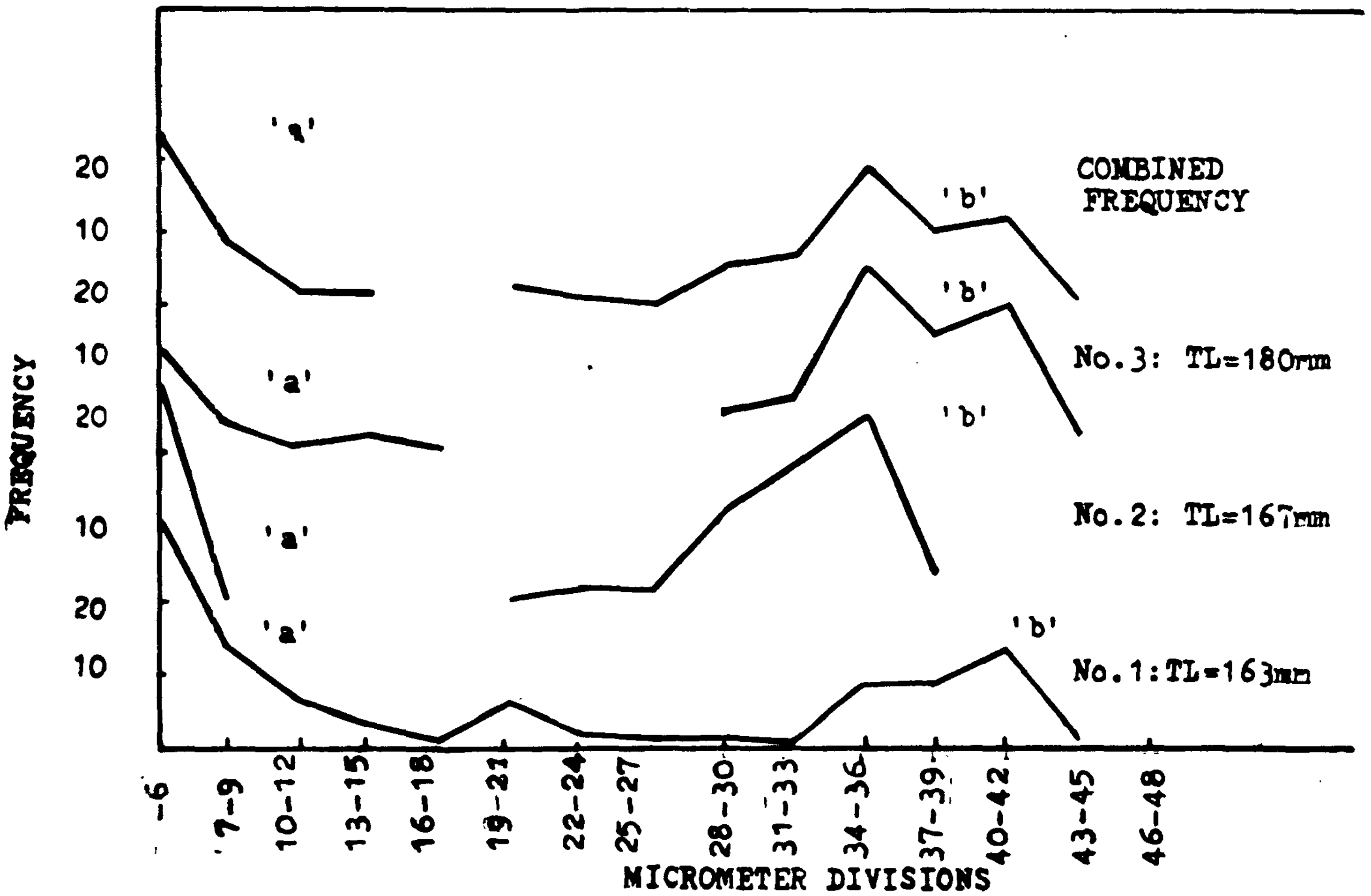
Specimens in stage III of maturity showed a wide

Text- Figure 13. Size distribution of ova from individuals of stage III of maturity in _Opisthopterus tardoore_ (Cuvier). The number of fish in each curve is given in brackets

Text-Figure 12. Size frequency distribution of ova from mature females of _Opisthopterus tardoore_ (Cuvier).

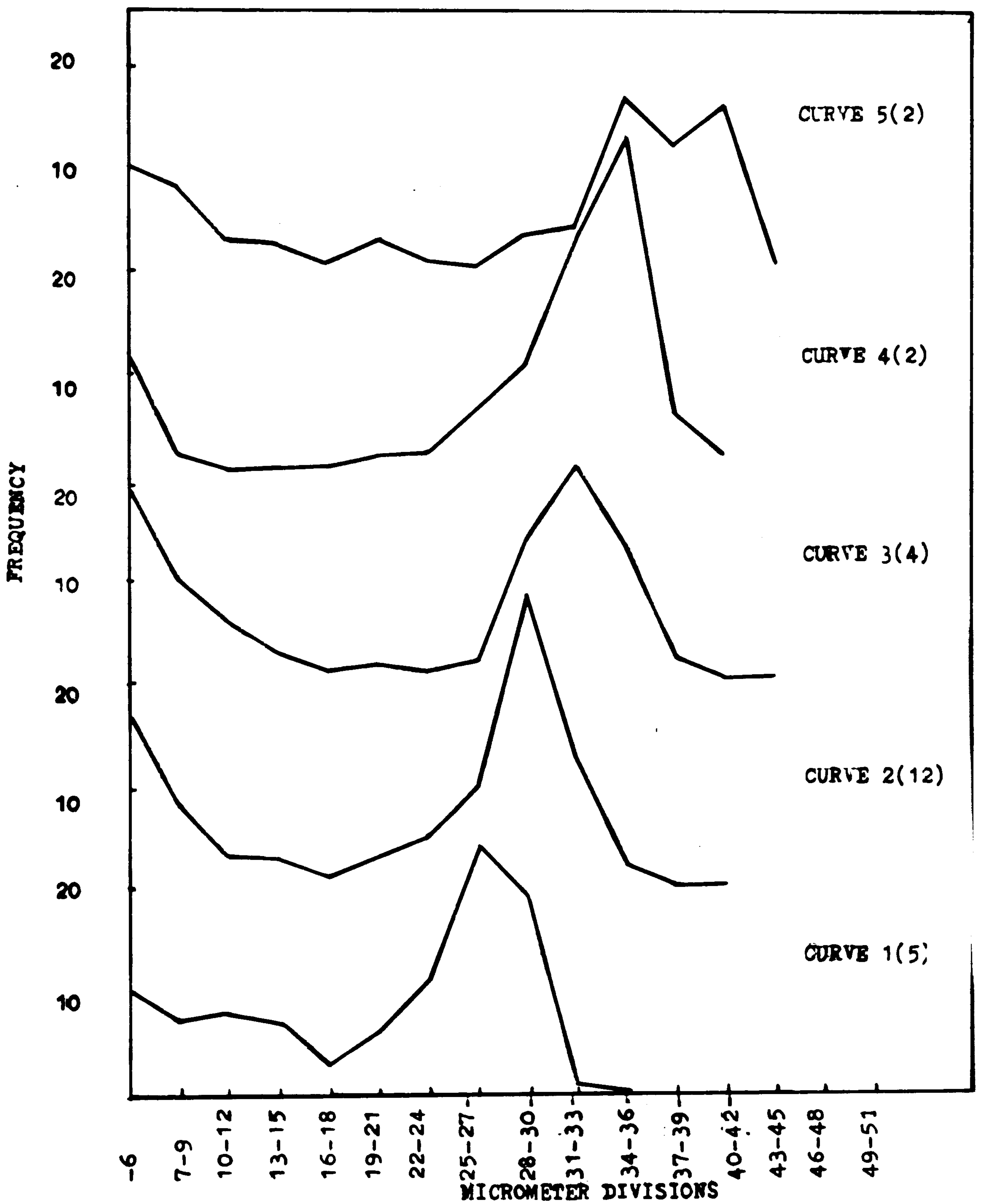


20
10
20
10
20
10
20
10
FREQUENCY
COMBINED FREQUENCY
APRIL 1960(5)
MARCH 1960(4)
FEBRUARY '6C(1)
7-9
10-12
13-15
16-18
19-21
22-24
25-27
28-30
31-33
MICROMETER DIVISIONS



20
10
20
10
20
10
20
10
FREQUENCY
'a'
'a'
'a'
'a'
'b'
'b'
'b'
'b'
COMBINED FREQUENCY
No.3: TL=180mm
No.2: TL=167mm
No.1: TL=163mm
-6
7-9
10-12
13-15
16-18
19-21
22-24
25-27
28-30
31-33
34-36
37-39
40-42
43-45
46-48
MICROMETER DIVISIONS

Text-Figure 14. Ova diameter frequency polygons showing the growth of the eggs to maturity. Each frequency represents measurements of ova from more than one female. Material taken at Karwar between February-April, 1960. The number of fish included in each curve is given in brackets.

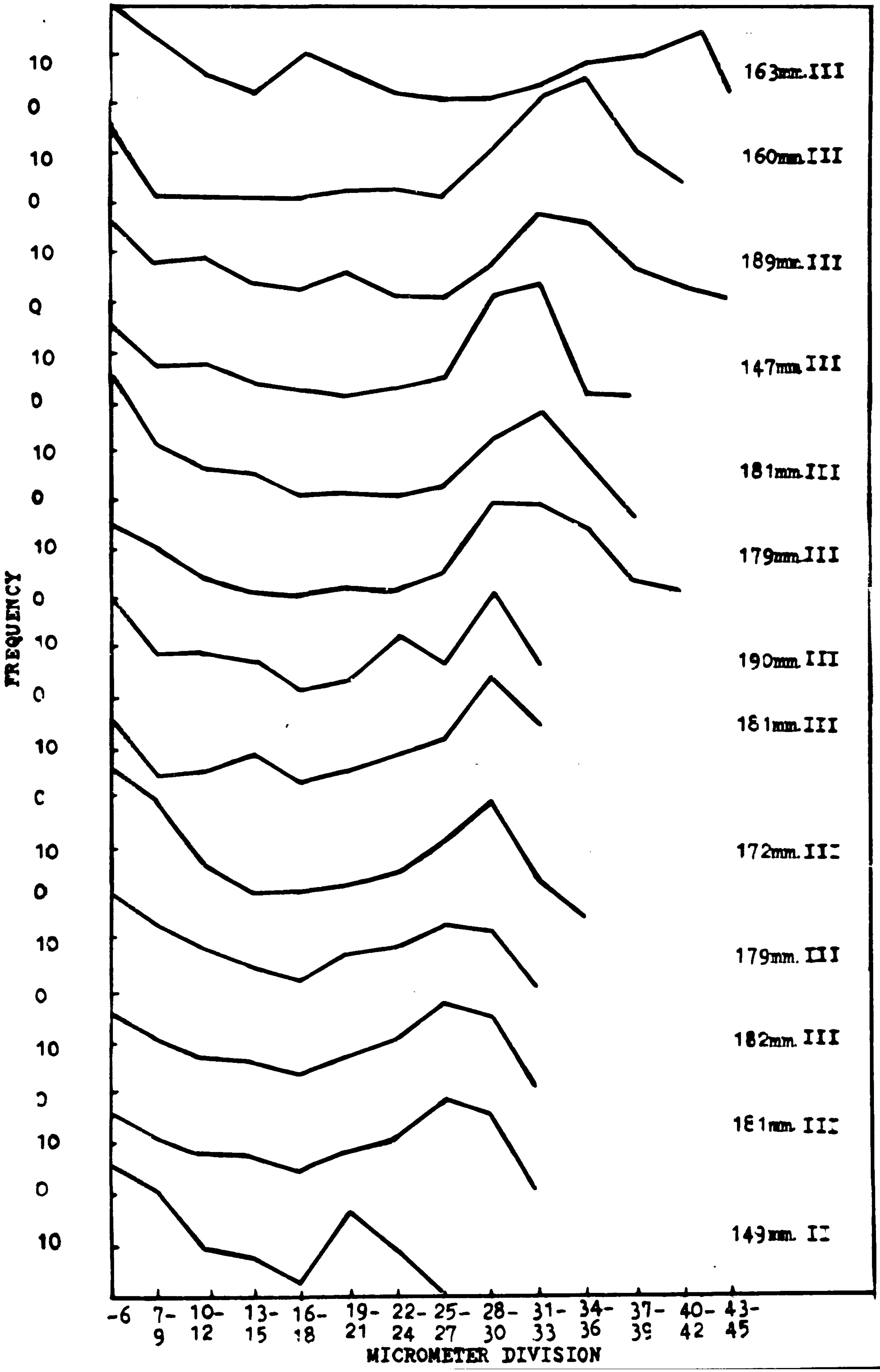


FREQUENCY
20
10
20
10
20
10
20
10
20
10
CURVE 5(2)
CURVE 4(2)
CURVE 3(4)
CURVE 2(12)
CURVE 1(5)
-6
7-9
10-12
13-15
16-18
19-21
22-24
25-27
28-30
31-33
34-36
37-39
40-42
43-45
46-48
49-51
MICROMETER DIVISIONS

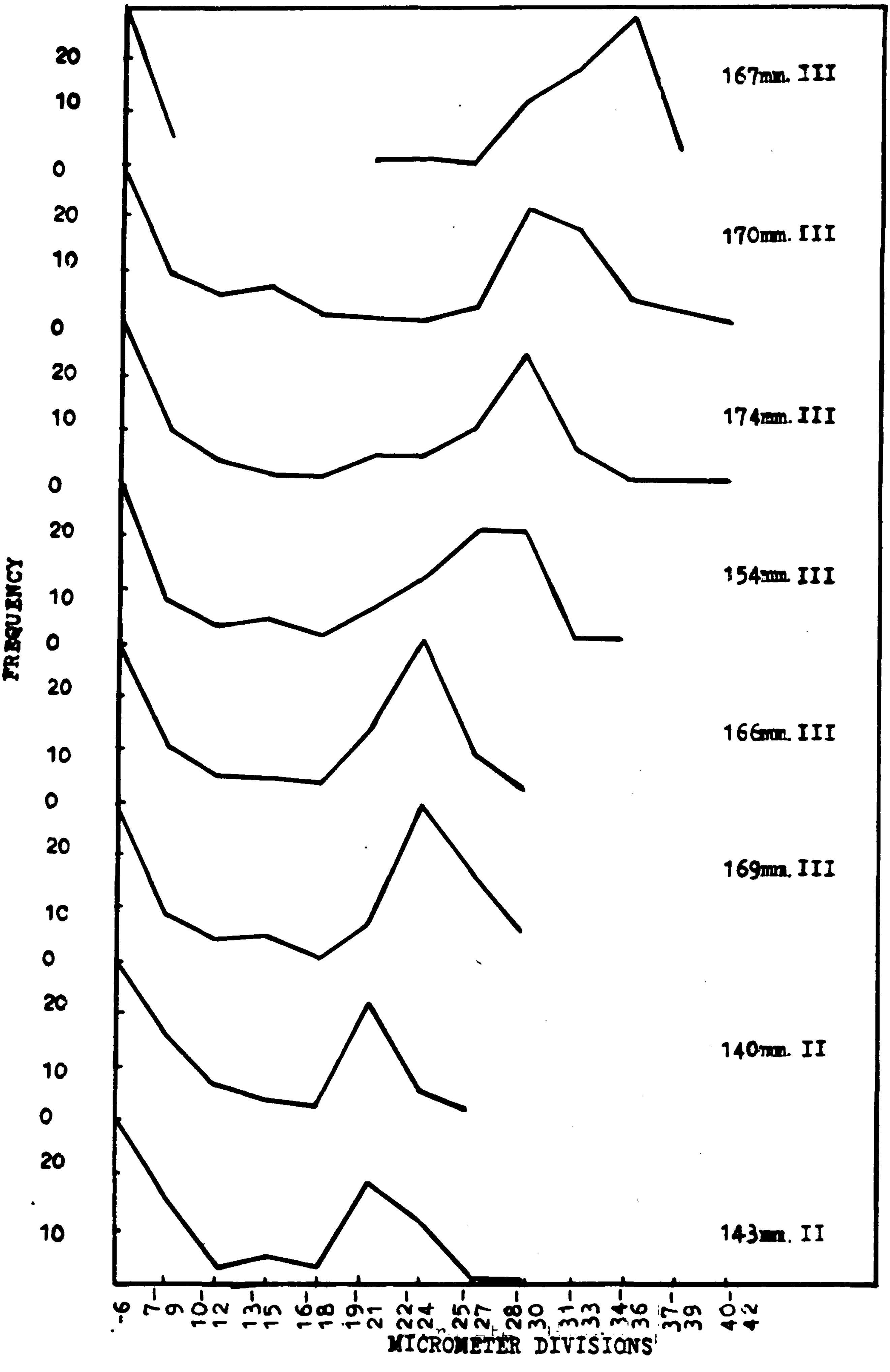
range in size of the eggs, the range being from 0.425 mm. to 0.765 mm. The frequency polygons showing the growth is illustrated in Text Figure 14. The differences in the height of peak seen in individual curves indicate the state of maturity of the eggs in different fishes. The data collected from 13, 8 and 20 specimens during February, March and April 1960 respectively are illustrated in Text Figure 15, 16 and 17. At the beginning one batch of ova from the immature group starts growing gradually. It increases in size and finally forms a single group of mature ova as shown in curves 4 and 5 of Text Figure 14.

Text Figure 18 gives the ova size frequencies in the ovaries of a ripe female measuring 185 mm. obtained at Karwar in March 1960. In this curve, there is a preponderance of small immature eggs upto 0.221 mm. At 0.323 mm. to 0.357 mm. there is a peak (b) of maturing group. This is followed by a gap in the curve and another distinct group (c) of larger eggs whose diameters vary from 0.731 mm. to 1.020 mm. The last group represents those eggs which are reaching peak maturity. These will be liberated during the forthcoming spawning season. The ova of mode 'b' are very small, as compared to those at mode 'c'. The presence of the maturing ova in mode 'b' suggests that this batch of eggs forms the stock of later years. Since these eggs only measure 0.510 mm. in diameter, it seems unlikely that these will attain the size of 1.020 mm., shown by the fully ripe

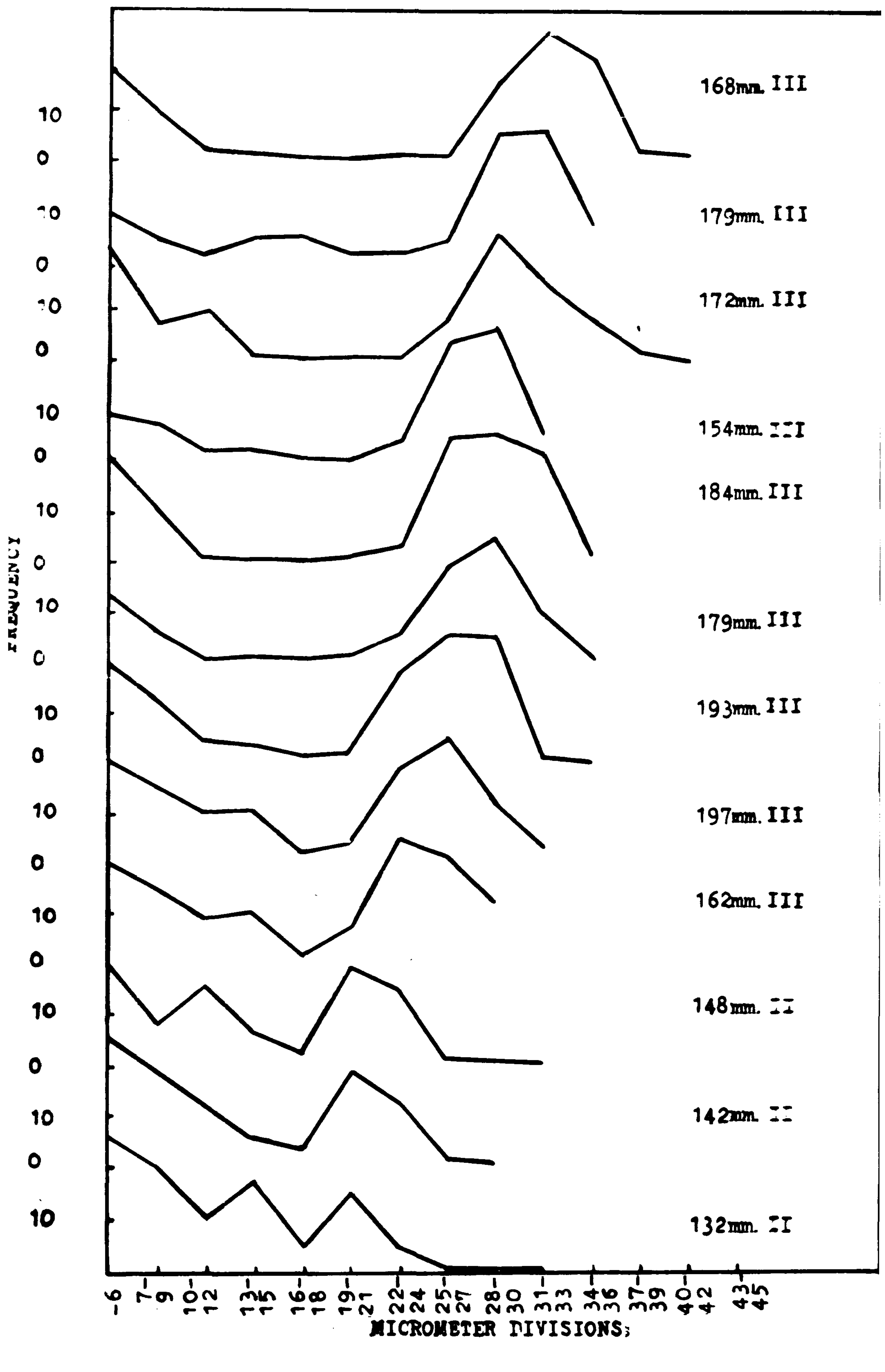
Text-Figure 15. Ova diameter frequency polygons for 13 females taken at Karwar for February, 1960. (The total length of the fish and the stages of maturity are indicated in each curve)


FREQUENCY
10
0
163mm. III
160mm. III
189mm. III
147mm. III
181mm. III
179mm. III
190mm. III
181mm. III
172mm. III
179mm. III
182mm. III
181mm. III
149mm. II
-6
7-9
10-12
13-15
16-18
19-21
22-24
25-27
28-30
31-33
34-36
37-39
40-42
43-45
MICROMETER DIVISION

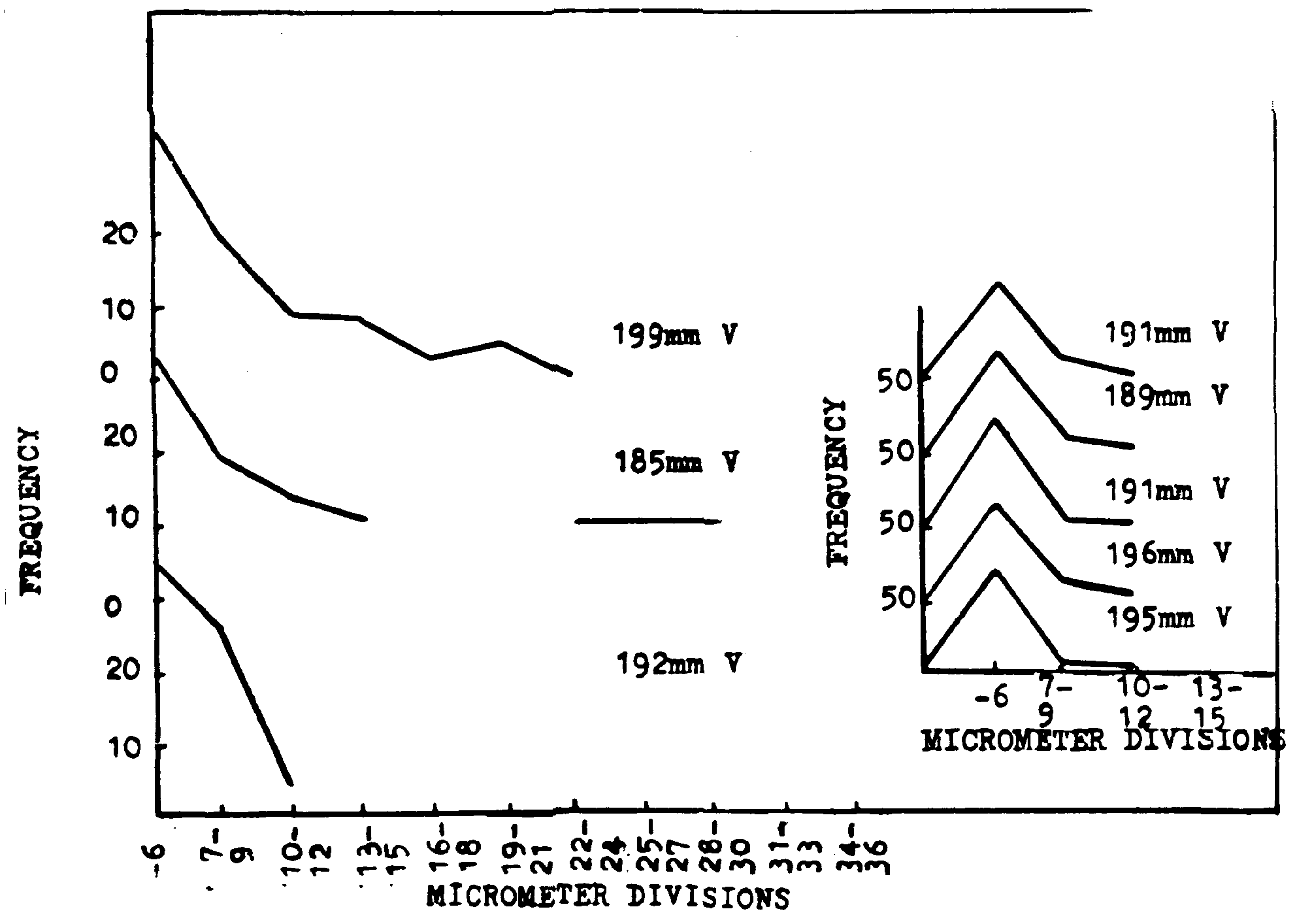
Text-Figure 16. Ova diameter frequency polygons for eight females taken at Karwar for the month of March, 1960. The total length of the fish and the stages of maturity are indicated in each curve.


FREQUENCY
20
10
0
167mm. III
170mm. III
174mm. III
154mm. III
166mm. III
169mm. III
140mm. II
143mm. II
6-7
9-10
12-13
15-16
18-19
21-22
24-25
27-28
30-31
33-34
36-37
39-40
42
MICROMETER DIVISIONS

Text-Figure 17. Ova diameter frequency polygons for 12 females taken at Karwar for the month of April 1960. The total length of the fish and the stages of maturity are indicated in each curve.

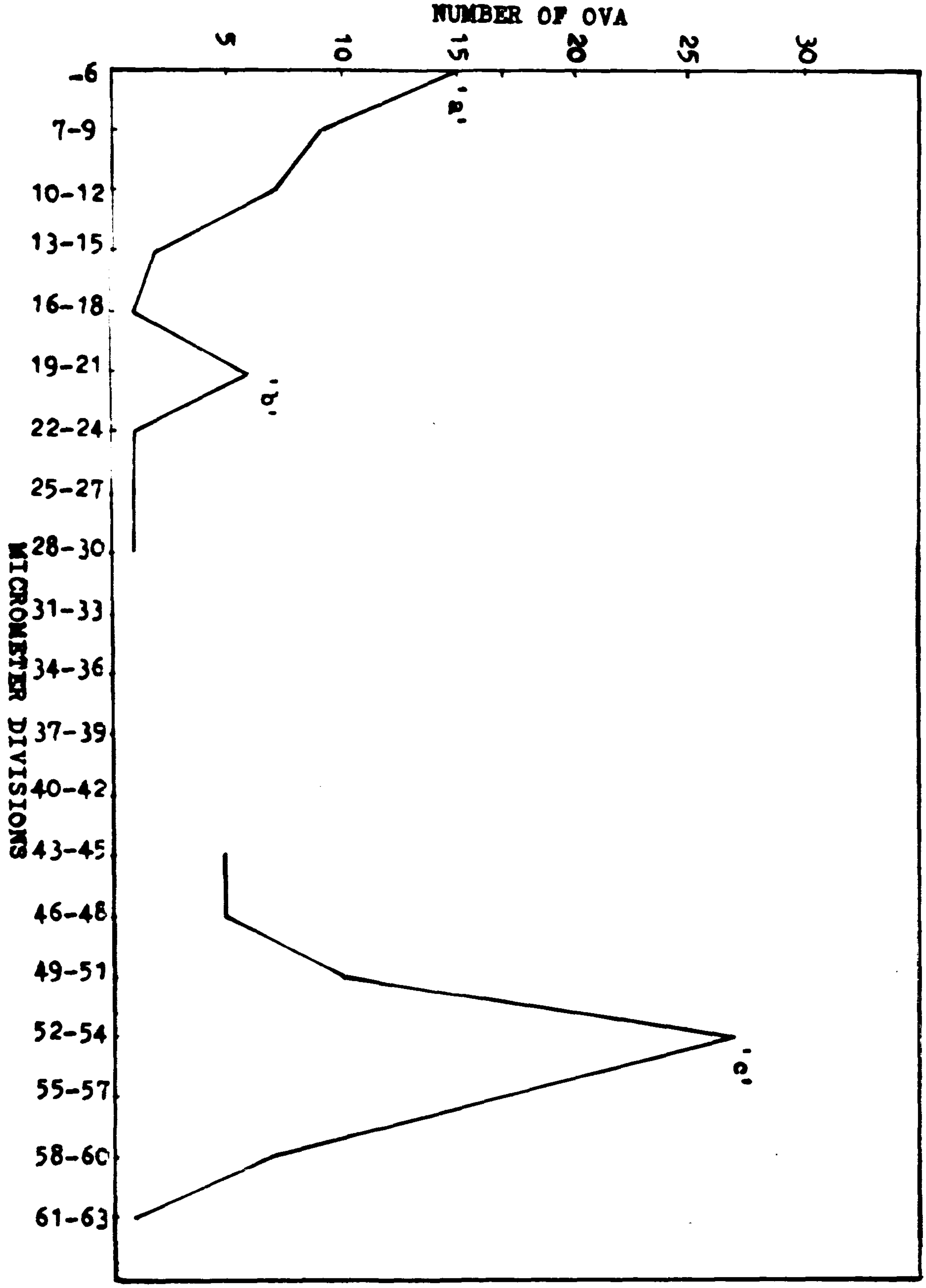

FREQUENCY
MICROMETER DIVISIONS
168mm. III
179mm. III
172mm. III
154mm. III
184mm. III
179mm. III
193mm. III
197mm. III
162mm. III
148mm. II
142mm. II
132mm. II

Text-Figure 17. Ova diameter frequency polygons for eight spent females taken at Karwar for April 1960. The total length of the fish and the stages of maturity are indicated in each curve.



FREQUENCY
20
10
0
20
10
0
20
10
199mm V
185mm V
192mm V
-6
7-9
10-12
13-15
16-18
19-21
22-24
25-27
28-30
31-33
34-36
MICROMETER DIVISIONS
FREQUENCY
50
50
50
50
191mm V
189mm V
191mm V
196mm V
195mm V
-6
7-9
10-12
13-15
MICROMETER DIVISIONS

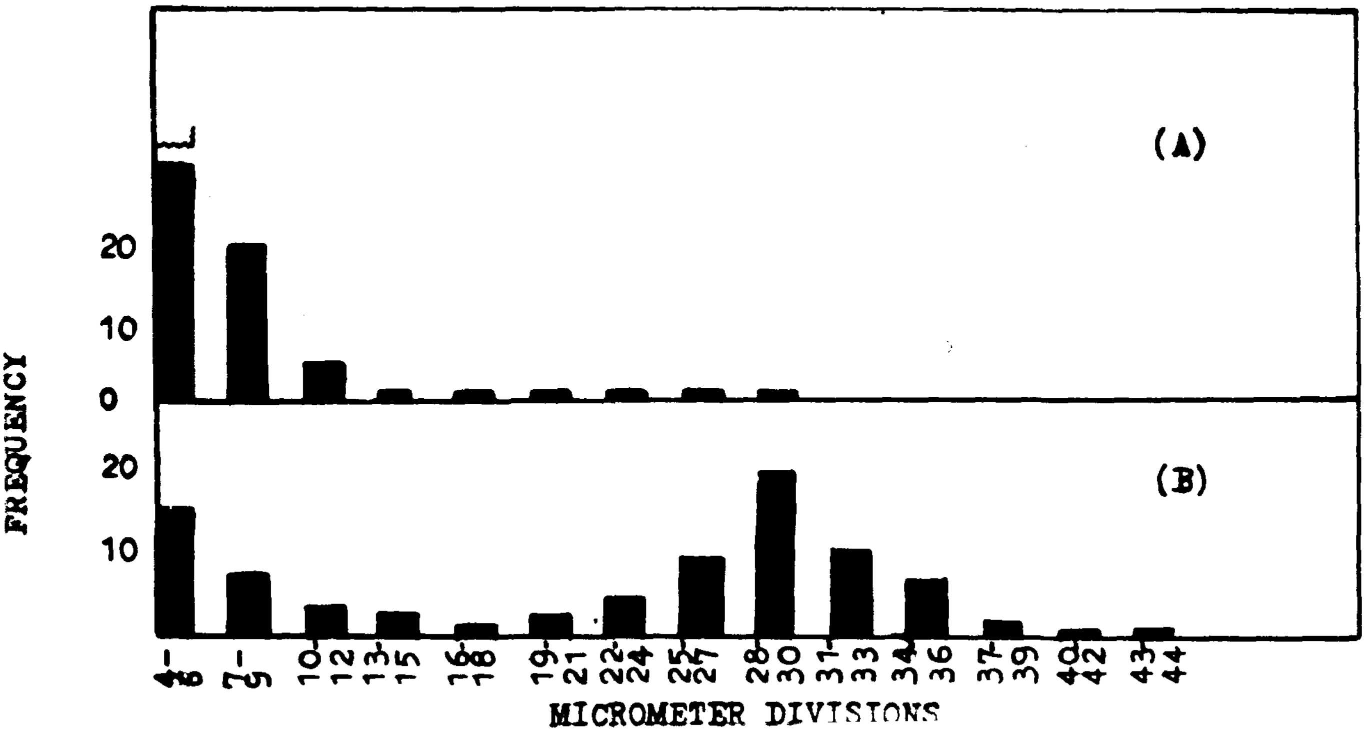
Text-Figure 18. Size distribution of ova from an individual measuring 185 mm. (Stage IV of maturity) in <u>Opisthopterus tardoore</u> (Cuvier)


NUMBER OF OVA
5
10
15
20
25
30
MICROMETER DIVISIONS
-6
7-9
10-12
13-15
16-18
19-21
22-24
25-27
28-30
31-33
34-36
37-39
40-42
43-45
46-48
49-51
52-54
55-57
58-60
61-63
'a'
'b'
'c'

ova of mode 'c'. Therefore, the ova at mode 'b' in all probability form brood of subsequent years. During the coming breeding season only those belonging to mode 'c' will be spawned. This make it quite clear that each individual of this species spawns only once a year.

The histograms 'a' and 'b' in Text Figure 19 have been based on 3300 intra-ovarian eggs from eleven spent individuals and 11943 ova from thirty four ripening individuals respectively. It is clear from the histogram 'a' that in spent fishes there is a single group of immature ova. This may be sometimes accompanied by some residual eggs of the earlier batch. Since in spent ovaries, a clear egg stock measuring more than ~~above~~ 0.510 mm. is not found, it indicates that all the ova measuring 0.510 mm. and above are shed during the spawning season.

Text-Figure 19. Frequencies of ova in 11 spent ovaries and 34 mature ovaries in Opisthopterus tardoore (Cuvier)


(A)
(B)
FREQUENCY
0
10
20
10
20
MICROMETER DIVISIONS

8. Spawning season its duration and occurrence of young ones.

The time of appearance of the smaller fishes (0-year group) and the occurrence of spent individuals seem to indicate that the spawning season of this species lasts from February or March to July and August. Ripening individuals (stage III) are noticed in the commercial catches during February and March, which indicates that the spawning season is approaching. Fishes with advanced stages of maturity (stage IV) could not be obtained in large numbers during the period of investigation, despite the fact that sampling was done continuously. However, some stray specimens with stage IV (ripe) were obtained in March. Spent and recovered spents (stages V and II) were abundantly recorded from March to August. This shows that the spawning had already taken place. For the first time during the season the entry of the young individuals into the fishery was noticed during May. These observations clearly indicate that the spawning season of this species commences in late February or early March and extends upto July or August.

Because of the notable absence of individuals with fully ripe gonads along the coastal waters and the reappearance of spent and recovering fishes along the coast, it seems reasonable to suppose that this species migrates into offshore waters beyond the existing fishing limit for the purpose of spawning. The conclusion is further supported by the fact that so far neither the eggs nor the larvae have been collected from the coastal plankton samples.

9. Length-weight relationship

As understanding of the length-weight relationship of the fish is of great value to the fishery biologist. A detailed account of the methods and their usefulness in fishery biology has already been given by Le Cren (1951).

In the present study 552 specimens ranging from 50 mm. to 209 mm. in size were measured and weighed. The total range in size was divided into eight size groups with a difference of 10 mm. and the mean length (L) and weight (W) in each size group was calculated. The equation $W = AL^B$ was followed in the present study, where W and L represent the weight and length of the fish respectively, A and B are the constants to be determined. The value of the constant B vary between 2.5 to 4. (Hile 1936 and Martin 1949). For all ideal fish the value for B has been found to be 3 (Allen 1938). The following procedure was adopted to find ~~out~~ the theoritical weight at a given length:

$$Y = A' + BX \text{ where X is log of L}$$

$$B = \frac{\Sigma XY - n\bar{X}\bar{Y}}{\Sigma X - nX^2}$$ where Y is log W and n the number of observation.

$$A' = \frac{\Sigma Y - B\Sigma X}{n}$$

$$W = AL^B \text{ where A is antilog of A'}$$

This analysis ~~lead~~ led to a close agreement between the observed and calculated set of values. The weight-length relationship formula was found to be $W = 0.004508 \ L^{2.2897}$.

10. Ponderal index

It has been well established by several earlier workers that the study of ponderal index or the coefficient of condition gives an important clue towards the understanding of some important features of the biology of fishes. Hickling (1930), Hart (1946), Morrow (1951), Qasim (1956,1957) and Bapat (1959) have correlated the fluctuations in the ponderal index with the attainment of maturity and spawning. The weight-length data discussed in the previous section were analysed for ~~the~~ various size groups. Throughout the work the weight-length coefficient 'K' was calculated by employing the formula used by Hickling (1930) and Hart (1946).

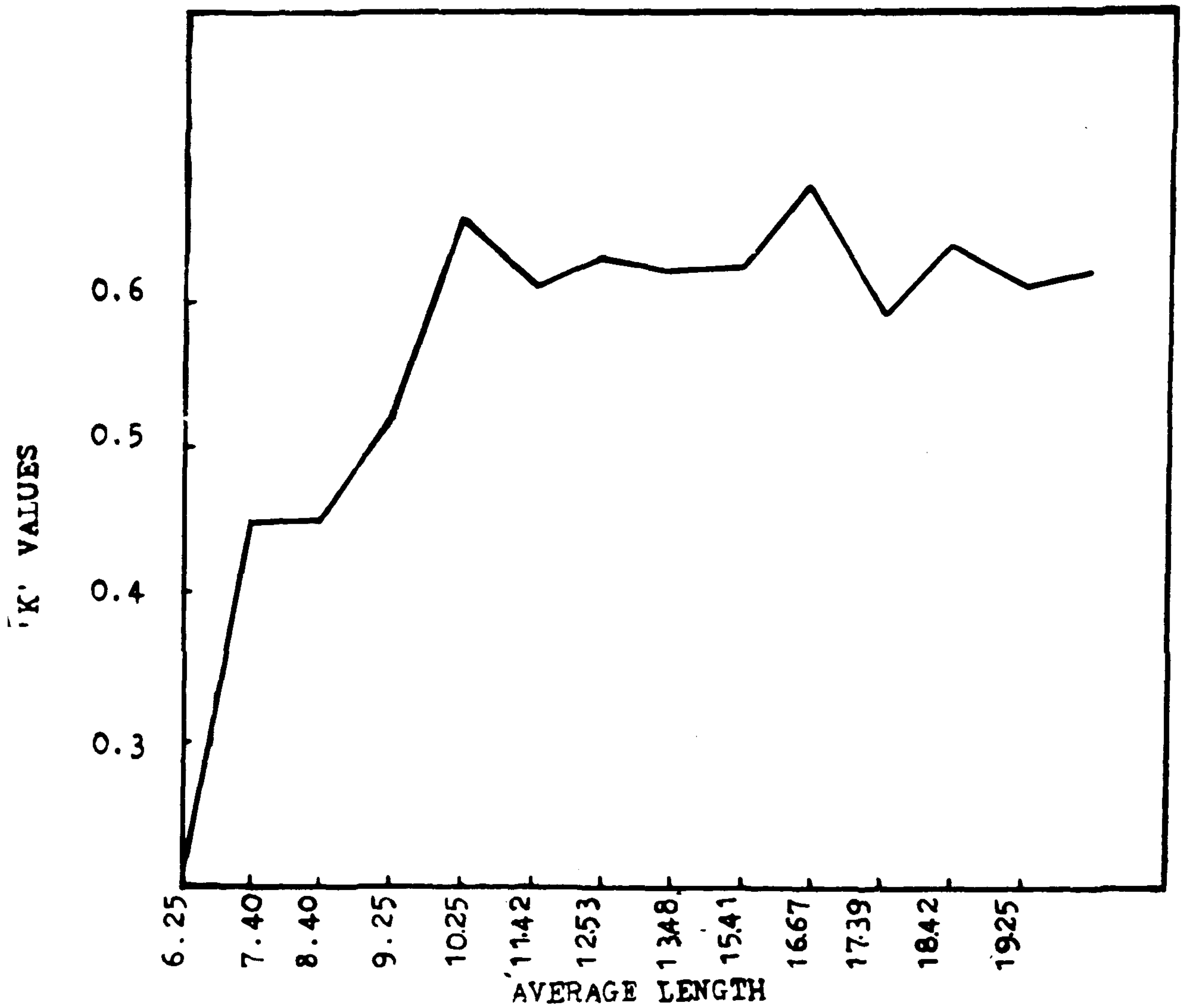
$$K = W/L^3 \times 100$$

where W is the weight of the fish in grams and L the length of the fish in centimeters and K the ponderal index. In determining the value of K all size groups ranging from 60 mm. to 199 mm. were taken into account.

The K values of various size groups have been given in Text Figure 20. Hart (1946) in the report on the trawling surveys on the Patagonian continental shelf has stated that the 'K' values may be give a very good idea of the broad outline of the seasonal cycle for the species. He observed that "apart from the seasonal variation in condition there is a secondary variation related to the length of the fish. With increase in age there is a lower level of condition throughout the seasonal cycle consequent upon the increased metabolic strain of spawning. The point of inflexion on a curve showing this diminution of 'K' with increasing length is thus a good approximate indication of the length at which sexual maturity is attained."

It is seen from Text Figure 20 that the first point of inflexion in the female is at 100 mm. Studies on the seasonal changes of gonad~~s~~ conditions have indicated that ~~the~~ fishes at this length are ~~in~~ at a very early stage of maturity. Therefore this inflexion does not seem to be related to the maturation cycle of the fish. It is perhaps related to some other factor. At 150-159 mm. group the 'K' values are lower than the preceding groups. This may be attributed to increasing metabolic strain due to spawning. If this point is taken as a point of inflexion of the curve and consequently the size at which first maturity is attained, it falls in good agreement with the more direct evidence obtained by the study of gonads.

Text-Figure 20. Average 'k' values of <u>Opisthopterus tardoore</u> (Cuvier) for different size groups.



'K' VALUES
0.6
0.5
0.4
0.3
6.25
7.40
8.40
9.25
10.25
11.42
12.53
13.48
15.41
16.67
17.39
18.42
19.25
AVERAGE LENGTH

11. Length frequency studies

The '*pachki*' fishery, as is commonly known in Kanarese commences from May and extends upto September or at times upto the beginning of October. Length frequency studies are based on samples taken in the inshore fishing grounds around Karwar. This species was mainly caught at Karwar in the shore seine nets, *yendi* and *rampan*. A total 9304 specimens from 107 samples were measured during the period of investigation. Text Figures 21 to 25 show the length frequency distribution of *Opisthopterus tardoore* during 1956 to 1960.

1956: This season lasted only for three months i.e. June to August. The size range recorded for June, July and August were 51-186 mm, 61-146 mm. and 61-146 mm. respectively. The frequency polygon for June has three modes at 60-69 mm; 80-89 mm. and 120-149 mm. size groups. But the fishery of 1956 was dominated by individuals of the 80-89 mm. size group. It is further noticed that a slight increase in length has occurred during July and August. It seems reasonable to believe that the mode 'a' seen at 80-89 mm. group in Text Figure 21, from June to August, represents individuals that have spawned sometimes towards the end of the previous spawning season. The mode 'a' seems to belong to the 1955 year class and the specimens ranging from 50-69 mm. and 130-149 mm. seen in June belong to the 1956 and 1954 year classes respectively.

<u>1957:</u> The season commenced in June and extended upto September. Individuals ranging from 37-199 mm. in length were netted. The range of size for different months is shown below:

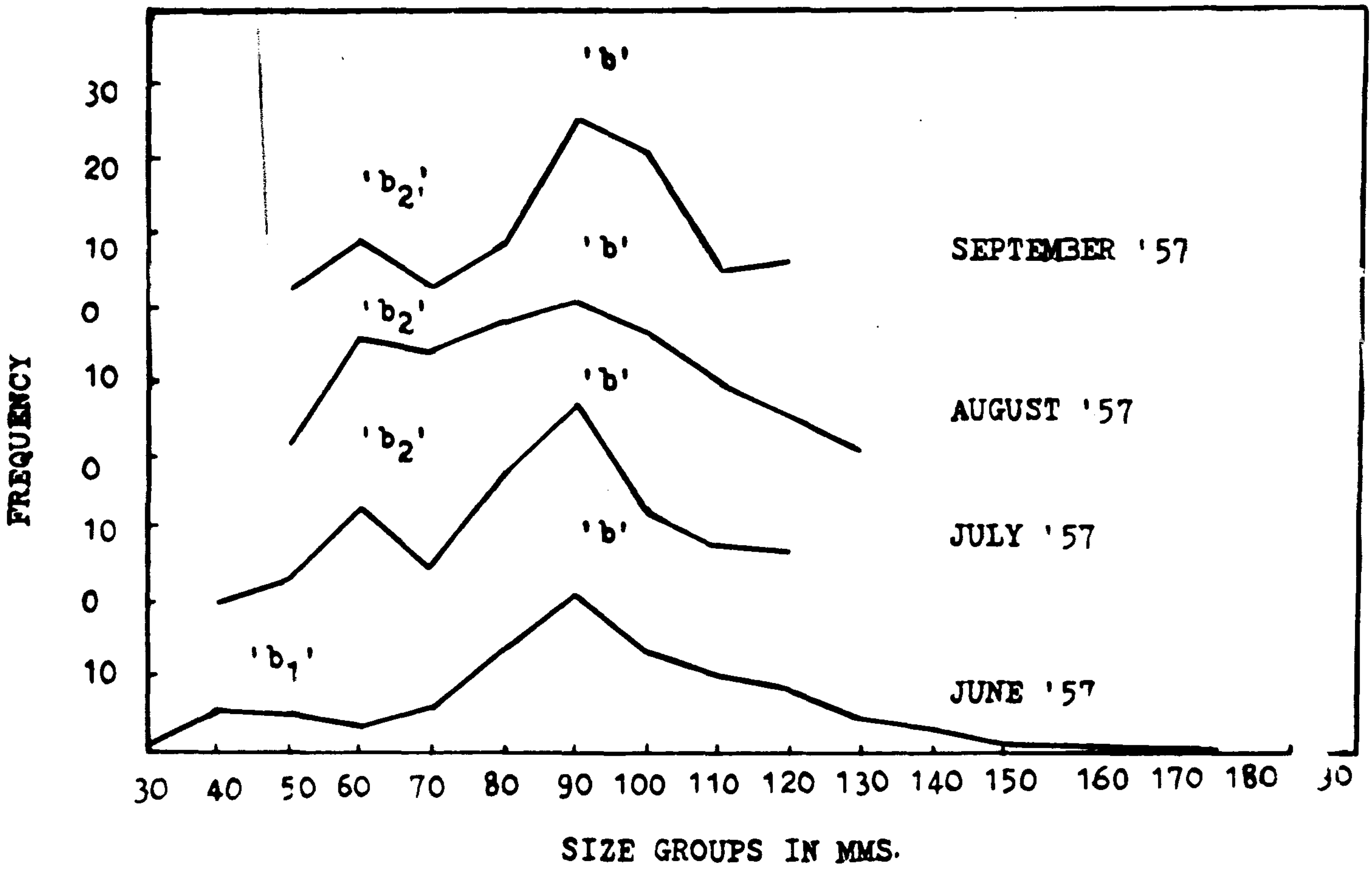
June	37-199 mm.
July	45-126 mm.
August	50-136 mm.
September	50-126 mm.

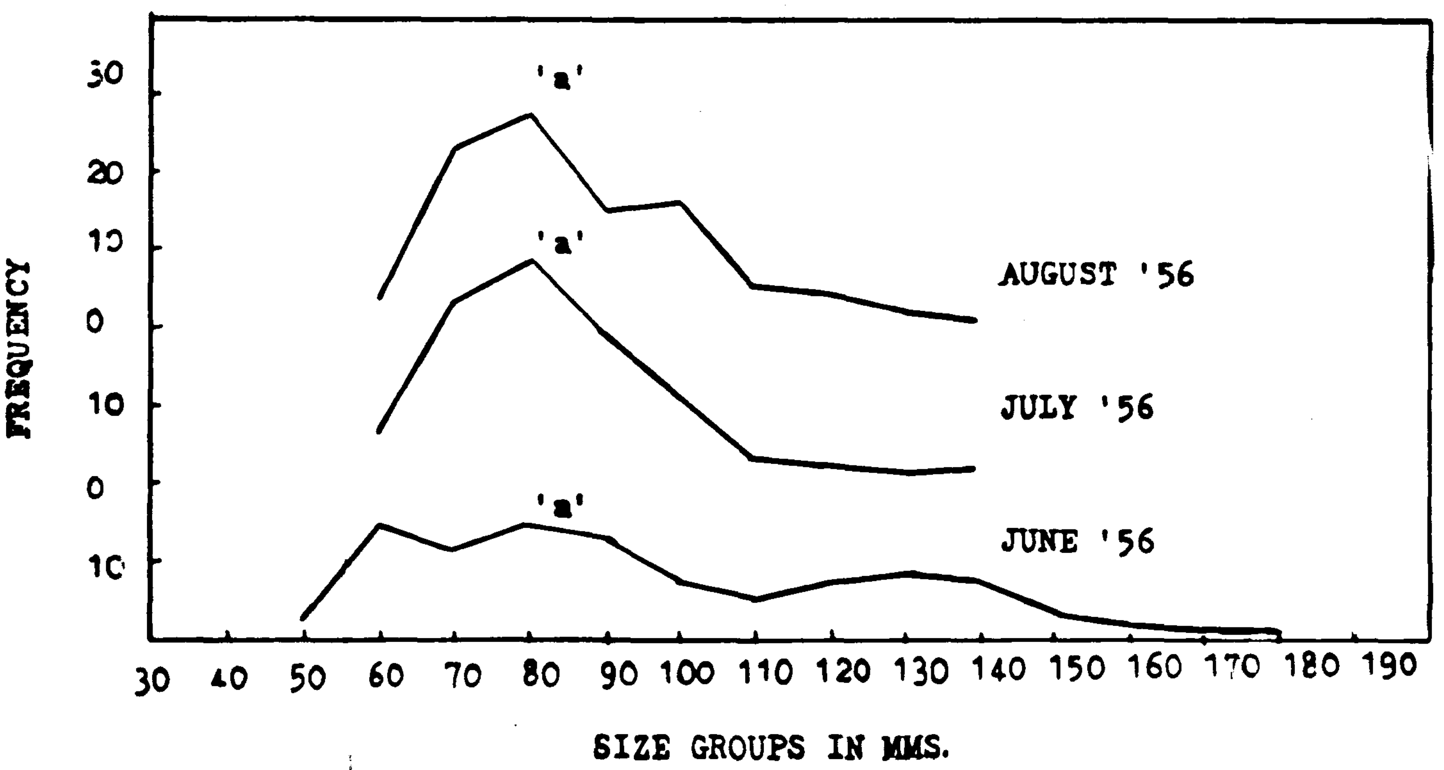
The 90-99 mm. size group 'b' predominated during the whole season (Text Figure 22). This category represents the 1956 year class and has more or less completed one year. The minor modes on the left side of 'b' seen in June, 'b_1' at 40-69 mm. and 'b_2' seen for July to September at 60-69 mm. belong to the 1957 year classes.

<u>1958:</u> The season commenced in May and ended in August. In May three modes at 90-99 mm., 140-149 mm. and 170-179 mm. were noted which represent the 1957, 1956 and 1955 year classes respectively (Text Figure 23). The 'b' mode (1956 year class) which contributed to the fishery of 1957 at 90-99 mm. is seen again during the 1958 season at 140-149 mm. This mode remained consistent throughout the season and therefore can be taken as the one, which belonged to I year class. It is seen that the fishery is mainly constituted by individuals in the 90-99 mm. size group. (mode 'c' - 1957 year class). In August, the mode 'c' has registered a 10 mm. increase in

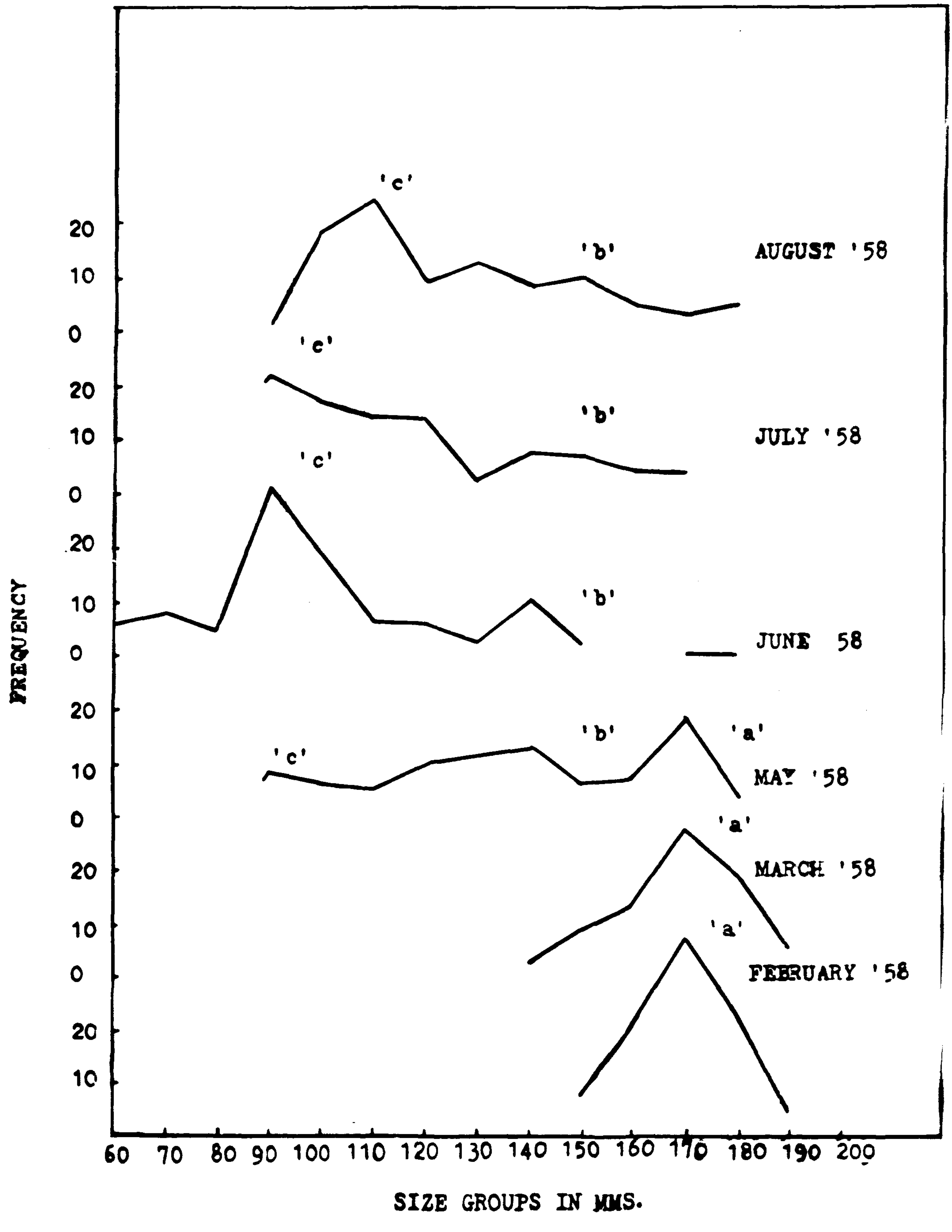
Text-Figure 22. Length frequency graph of the samples of *Opisthopterus tardoore* (Cuvier) collected at Karwar during 1957.

Text-Figure 21. Length frequency graph of the samples of *Opisthopterus tardoore* (Cuvier) collected at Karwar during 1956.


'b'
'b2'
'b'
'b2'
'b'
'b2'
'b'
'b1'
SEPTEMBER '57
AUGUST '57
JULY '57
JUNE '57
FREQUENCY
30
20
10
0
10
0
10
0
10
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
SIZE GROUPS IN MMS.


'a'
'a'
'a'
AUGUST '56
JULY '56
JUNE '56
FREQUENCY
30
20
10
0
10
0
10
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
SIZE GROUPS IN MMS.

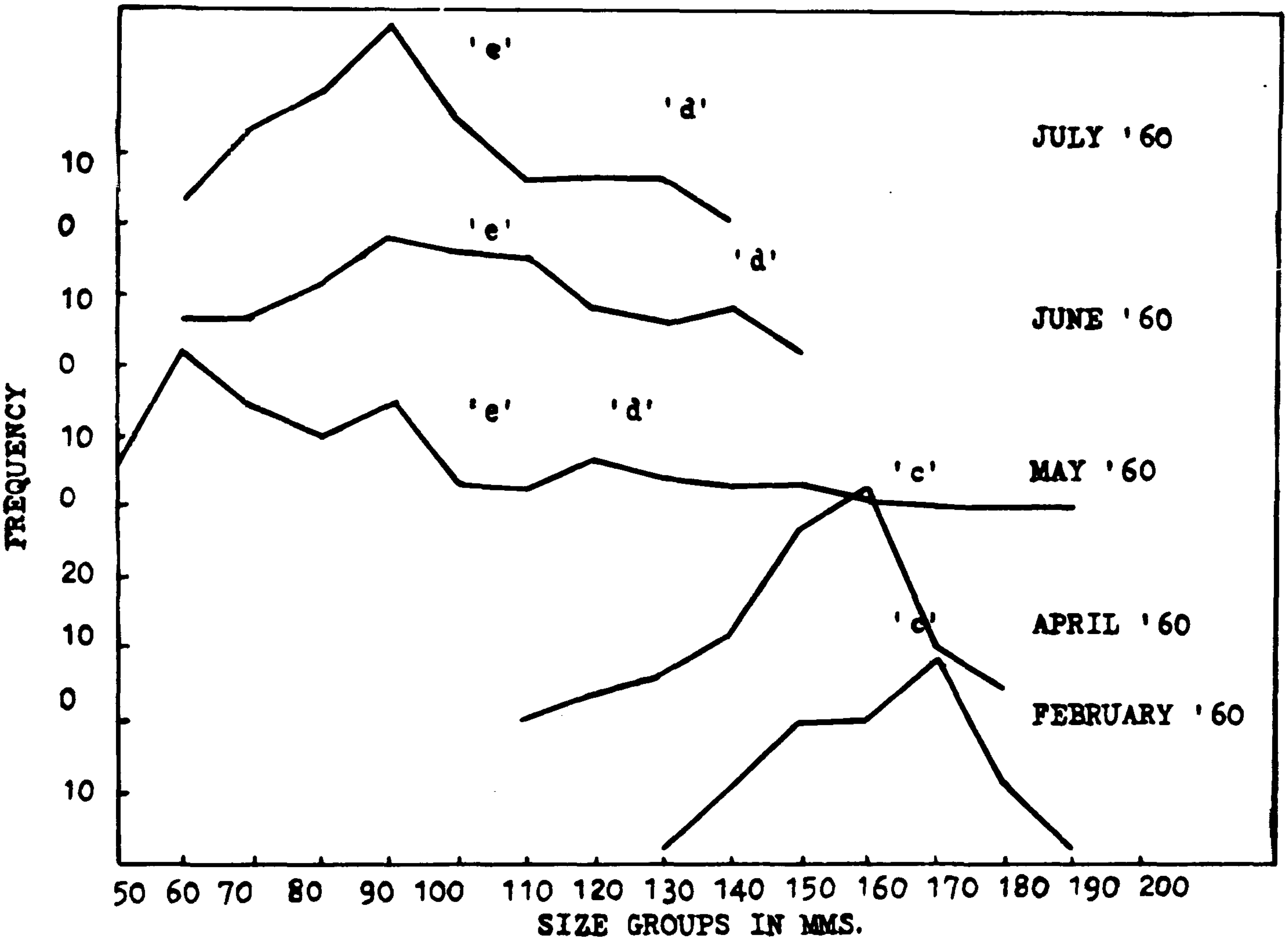
Text-Figure 23. Length frequency graph of the samples of *Opisthopterus tardoore* (Cuvier) collected at Karwar during 1958.

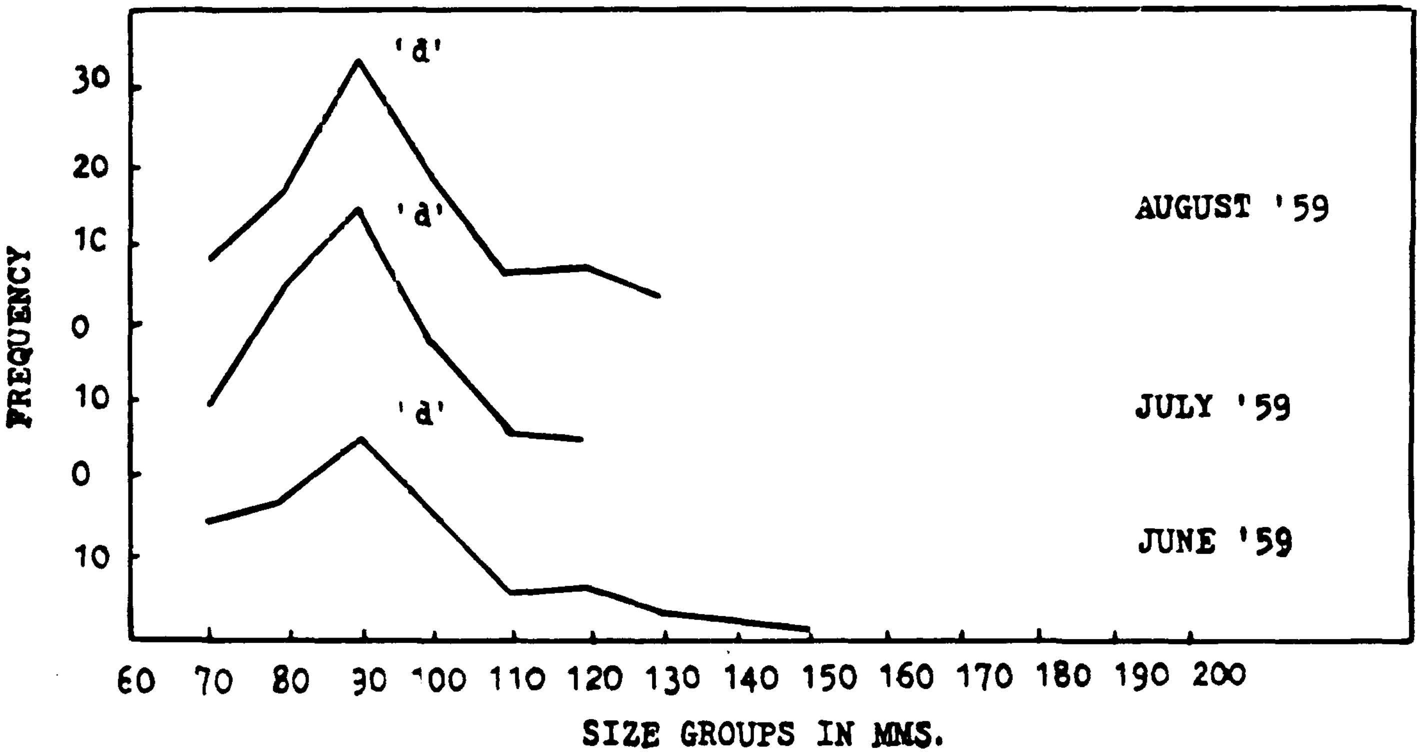


FREQUENCY
20
10
0
20
10
0
20
10
0
20
10
0
20
10
0
20
10
'c'
'b'
AUGUST '58
'c'
'b'
JULY '58
'c'
'b'
JUNE 58
'c'
'b'
'a'
MAY '58
'a'
MARCH '58
'a'
FEBRUARY '58
60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
SIZE GROUPS IN MMS.

Text-Figure 25. Length frequency graph of the samples of <u>Opisthopterus</u> <u>tardoore</u> (Cuvier) collected at Karwar during 1960.

Text-Figure 24. Length frequency graph of the samples of <u>Opisthopterus</u> <u>tardoore</u> (Cuvier) collected at Karwar during 1959.


'e'
'd'
JULY '60
'e'
'd'
JUNE '60
'e'
'd'
'c'
MAY '60
APRIL '60
FEBRUARY '60
FREQUENCY
10
0
10
0
10
0
20
10
0
10
50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
SIZE GROUPS IN MMS.


'd'
'd'
'd'
AUGUST '59
JULY '59
JUNE '59
FREQUENCY
30
20
10
0
10
0
10
60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
SIZE GROUPS IN MMS.

length ~~growth~~. Thus, the 1958 '<u>pachki</u>' season appears to be mainly supported by individuals in the I and I+ year classes, in contrast to the 1956 and 1957 seasons where the fishery was constituted only by a single age group.

From February to May, large sized individuals were also netted in the shore seines. During these months fishes measuring 170-179 mm. in length dominated the catches. This mode is not seen representing the catches commencing from June, though slight indications of its presence is seen during August. This group is the continuation of the mode 'a' seen from June to August 1956, which seems to be the progeny of the fish that has spawned in 1955. During 1957 this mode was not represented at all in the commercial catches. The size range recorded for different months of the year are as follows:

February	150-190 mm.
March	140-190 mm.
May	91-186 mm.
June	61-182 mm.
July	91-175 mm.
August	90-175 mm.

<u>1959</u>: The season lasted only for three months, June to August. The size range for June, July and August were 61-164 mm., 61-126 mm. and 60-146 mm. respectively. From the Text Figure 24, it can be seen that the dominant

size group in the months of the commercial fishery belonged to the 90-99 mm. group. The mode 'd' represents the 1958 year class, which has completed about one year. No other age group supported the fishery. The occurrence of larger individuals measuring 140 mm. and above were noted only in June.

1960: May to July were the main fishery months for the year. The size range for May, June and July were 51-179 mm., 61-157 mm. and 61-157 mm. respectively. The 90-99 mm. group (mode 'e' - 1959 year class) dominated the catches throughout the season. (Text Figure 25). The result of the recruitment of the new generation with a size 60-69 mm. is also seen in May in addition to the 90-99 mm. group. Individuals ranging from 120-149 mm. (mode 'd') also contributed to some extent towards the 1960 fishery, although this mode 'd' (1959 year class) was the main stay of the fishery during the 1959 season. Individuals with the size range 130-190 mm. and 113-189 mm. were netted during February and April respectively. The mode 'c' (1957 year class) which formed the fishery of 1958 is seen at 170-179 mm. in February. A notable feature in the frequency curve for the month of April is that the mode has moved downward instead of upward, which may probably be due to sampling error.

Discussion: This investigation covers a period of five years commencing from 1955 to 1960. The total number of fish measured during the period was 9304 consisting of adults and immature taken from 107 samples.

The range of size of specimens varied from 30 mm. - 200 mm. A study of the various size groups related to various years and their progression in successive months gave an indication that the '<u>pachki</u>' fishery at Karwar is dependent mainly upon two age groups. The modes 'a', 'b', 'c', 'd' and 'e' representing the year classes of 1955, 1956, 1957, 1958 and 1959 formed the mainstay of the seasons during 1956, 1957, 1958, 1959 and 1960 respectively. The size and month of the first appearance of these year classes for various fishery seasons have been shown in Table No.75

Table No.75

Mode and corresponding year class	season of abundance of the year class.	Month of appearance of the mode (year class)	Size of mode at the time of first appearance (mm.)
'a' - 1955	June-August 1956	June 1956	80-89
'b' - 1956	June-August 1957	June 1957	90-99
'c' - 1957	May-August 1958	May 1958	90-99
'd' - 1958	June-August 1959	June 1959	90-99
'e' - 1959	May - July 1960	May 1960	90-99

Length frequency studies of different seasons have shown that 80-89 mm. size group had the highest frequency during 1956. During succeeding fishery seasons the 90-99 mm. group was dominant. The 1958 and 1960 seasons were contributed by 140-149 mm. group in addition to the 90-99 mm. group. It is clear from the Text Figures 22 and 24 that the modes 'b' obtained during 1957 and 'd' obtained during 1959 include the same size groups of '<u>pachki</u>' fishery. Thus, the fishery of 1957 and 1959 was mainly supported by one year old fishes. In 1957 and 1959 seasons the fishery was mainly based on modes 'b' and 'd' which were preceding years broods. Their size in these years were 90-99 mm. During succeeding years i.e. 1958 and 1960 these groups appeared in the frequency polygons at 140-149 mm. Thus, one could see that during the 1958 and 1960 seasons the '<u>pachki</u>' fishery was mostly supported by I and I+ year old individuals. In 1956, the seasonal catch included 0-year group fishes also.

From the length frequency data, the growth rate of the fish appears to be slow, hence the monthly progression of various modes could not reveal any increase in size. However, the normal modal size of one year old '<u>pachki</u>' appears to be 90-99 mm. and at the end of second year of their life, the fish probably attains 140-149 mm. in length. It has been already indicated that the size of the '<u>pachki</u>' at first maturity is 150-169 mm. Keeping this in view, it appears that the fish probably matures after it has completed two years of ~~its~~ life.

From the details given above, it appears that the 'pachki' fishery draws little support from individuals above 160 mm. in total length. Owing to lack of sufficient data on the size groups above 160 mm., it is difficult to decide the total life span of Opisthopterus tardoore.

The otoliths and scales of Opisthopterus tardoore were studied. The opaque zones usually seen on the otoliths of fishes in temperate ~~temperature~~ waters are the regions where excessive calcification has taken place during the season. This occurs when growth of the fish is rapid. The translucent zones on the other hand are formed when growth is slow or has practically stopped. Even by employing the methods of clearing suggested by Nair (1949), no successful results were obtained as the zones on the otoliths remained indistinct. Hence the age of 'pachki' at different sizes could not be confirmed from otoliths or scale studies.

12. Food and feeding habits.

The material was mostly collected from the commercial catches at Karwar during March to July 1960. In other months of the year, only stray specimens were netted.

An exploratory examination of the stomach analysis showed that *Opisthopterus tardoore* is a carnivorous fish. To see if there were any difference in the composition of the diet in fishes of different sizes, the stomachs of about 410 specimens were examined. The food of *Opisthopterus tardoore* was found to compose of mainly *Mysids*, *Pseudodiatomus* and copepod eggs, their percentage in the total volume of food being 56.93, 18.52 and 10.28 respectively. The other items are *Acetes*, *Acrocalanus*, *Lucifer* broken fragments of crustacean appendages, prawns,bivalve eggs and larvae, *cypris* larvae, *Coscinodiscus* and amphipods. Fish larvae and packets of fish scales were also noticed. Sand grains were also seen in the stomachs.

An interesting fact noticed was that the specimens with 130 mm. and above in total length, showed preference towards *mysids*. Smaller individuals (70-100 mm.) on the other hand were found to contain mostly on *Pseudodiatomus*, copepod eggs and *Acrocalanus* in their stomachs. Table No.76 shows the percentage composition of different items of food recorded in the stomachs of *Opisthopterus tardoore* during

March-July 1960.

The total volume of food in the stomach ranged from 0.06 c.c. to 0.08 c.c. and the average volume of food per stomach for the period of observation works out to 0.072 c.c. The values for individual months for March, April, May, June and July were 0.06 c.c., 0.08 c.c., 0.08 c.c., 0.07 c.c. and 0.07 c.c. respectively. There appears to be no marked period of intensive feeding of Opisthopterus tardoore in the Karwar Bay.

On the basis of all the organisms recorded in the stomach it is concluded that this species has a carnivorous habit showing preference towards crustacean forms.

Table No.76

Food items	March	April	May	June	July
Mysids	97.76	67.09	8.36	68.85	26.38
Pseudodiatomus	...	...	90.40	0.81	...
Copepod eggs	...	...	...	20.60	...
Acrocalanus	2.23	...	...	5.03	1.38
Larval bivalves	...	...	...	2.81	...
Bivalve eggs	...	3.01	0.62	0.70	...
Acetes	...	...	...	...	67.67
Lucifer	...	12.12	...	...	...
Crustacean appendages	...	9.09	...	...	...
Prawn	...	3.89	...	...	...
Amphipods	...	...	...	0.81	...
Cypris larvae	...	...	...	0.11	4.16
Coscinodiscus	...	...	...	0.23	...
Fish larvae	...	...	0.93	...	...

(All figures mentioned above are percentages)

13. Fishing methods

Kanara has a coastline of about 200 miles. The magnitude of the immense wealth of natural resources of this comparatively small coastline, is revealed by its production which amounts to nearly one sixth of the total marine fish production of this country. The coastline has nearly 160 fishing villages with a total population of 80,000. The fishing population consists of Mogaveeras, Mogers, Bovi, Karvi, Harikanthas, Gabits, Daljits and Mapalas. Tulu, Kannada and Konkini are the main languages spoken in this area. Along the Kanara coast, fishing is generally carried out only upto 10 fathoms.

The '<u>pachki</u>' fishery is restricted to a short period. It commences in May and ends either in September or early October. The main fishery season extends from June to September, with a peak generally falling in the month of July.

<u>Opisthopterus tardoore</u> is a small sized fish commonly growing to about 170 mm. to 190 mm. in length. The maximum size recorded during the course of the present work being 216 mm. As regards its distribution, Day (1899) mentions it "from Gwadur in Beloochistan and Sind, through the seas of India to the Malaya Archipelago." Recently Nair (1953) has prepared a key for the field identification of the

common clupeiod fishes in India. The characters of this species were described by him as follows: "Height $3\frac{1}{2}$ to $3\frac{3}{4}$; Head 4 to 4 2/5; Eye $2\frac{3}{4}$ to 3. (The height, head and the eye proportions given in the key are in relation to the body length and to the length of head respectively.) Elongate, very compressed; highly convex from chin to anal; dorsal profile of head concave, of back slightly convex; dorsal short, its origin far behind that of anal; anal elongate; no ventrals; silvery pectorals and caudal with dull dusky dots".

A brief account on the crafts and the fishing methods commonly used for the '<u>pachki</u>' fishery along the Kanara coast is given below. The methods of fishing are very varied - the most important being the shore seines. It is also fished by gill nets, cast nets and drag nets. It is also caught by trawlers in small quantities off Cochin during Monsoon months.

Crafts

As in other parts of India, fishing ~~in~~ along Kanara coast is carried out by small crafts such as dug out canoes (<u>pati</u>) of various sizes, the plank built boat (<u>doni</u>) and the <u>rampan</u> boat (<u>pandi</u>). The boats and the canoes mentioned above are provided with outrigger equipment. The outrigger is formed by two curved bamboo poles and a float. The poles are laid across the boat and extend five to six feet on one side of the boat. They are so tied that the distance between the poles decreases towards one end. To these, is directly attached a light wooden float.

Nets

Three types of nets are commonly used, the shore seines (rampan and yendi balae), the gill net (pattabalae), the cast net (veechuvalae) and the drag net (gorbalae)

I. Shore seine fishing:

(a) Rampan net: This is the largest and one of the oldest gears used along this coast. Its origin dates back 80 to 85 years, when a Portugese priest called Father Rampani introduced this net into South Kanara. This net was named after him. It is believed, that this net was introduced at Chendia and Bingae by about 1926 and two years later at Karwar.

The net is made up of hemp or cotton and consists of many pieces. The number of pieces vary according to localities and the depth of inshore waters. In Karwar and neighbouring villages the net consists of 400 to 700 pieces, whereas in the southern half of Kanara, the number is sometime reduced to about 100 or at the most 200. The central pieces have very small meshes and this part is called 'chikkan balae'. The side nets have larger meshes and is termed as 'Alibalae'. The dimensions of the nets are as follows:

<u>Chikkanbalae</u>: 6' x 35' / $\frac{3}{4}$"

<u>Allibalae</u>: 16' x 37' / 1$\frac{1}{2}$" - 1$\frac{3}{4}$"

The end piece where the hauling ropes are attached measure 16' x 16' /1$\frac{1}{2}$" - 1$\frac{3}{4}$". The vertical portion of the net during operation is maintained by the attached wooden floats on the top end and a series of weights or sinkers attached to the bottom end.

The cost of a <u>rampan</u> consisting of 350-400 pieces and its accessories such as ropes etc., together with one large boat and one small <u>doni</u> comes to about Rs.20,000/-

The method of operation of the net is as follows:
The basic requirements for fishing with a <u>rampan</u> net are 60 to 80 men, one <u>pandi</u> (for carrying the net), 3 or 4 <u>doni</u>, one of which is used as a scout boat and the net comprising 400 to 600 pieces. The net is piled in 'V' layers in the <u>pandi</u>. Then, the <u>pandi</u> ~~then~~ is rowed out to sea in a direction perpendicular to the shore. As it proceeds, the rope is paid out and on reaching the other end of the rope, the boats are geared in a semicircle. The free end of the lead rope which was taken to the shore at the commencement of the operation, is taken in hand and 20 to 25 men depending on the size of the net start pulling. The <u>pandi</u> completes a semicircle by the time the whole net is paid out and it is now steered towards the shore in a line

parallel to the first lead rope. Thus, it comes very close to the shore and after the lead rope at the other end of the net is handed over to another batch of fishermen stationed there, the pandi is rowed in a reverse direction and is anchored at the centre of the circumscribed net. The net is then dragged shorewards.

(b) Yendi: This is smaller in size and consists of 50 to 60 pieces. A single piece measures 13' x 13' /¾". This is made up of hemp or cotton. This is mainly worked during rainy season in sheltered bays within a range of about two furlongs from the shore. The man power required for the operation of this net is about 8 to 12 . The approximate cost of a single piece works out to Rs.25-30. The method of operation of this net is more or less the same as that of rampan.

II. Gill net

(a) Pattabalae: The pattabalae fishing is conducted at the surface or at mid-water. The net is usually made up of cotton twine and rarely of hemp. The net consists of a number of pieces varying from 20 to 30. Each piece measures 26' - 27' / 1½" - 1¾". The approximate cost of one piece is about Rs.40/- The net is operated in shallow waters to enable the net to reach the bottom . To the head rope of the net are tied a number of floats and the bottom is provided with weights which may be stones or lead pieces. This helps the suspension of net vertically in the water. When a shoal is sighted, the gill net is set around the school of fish. Loud noises are produced by beating the sides of the boat. The encircled fishes when scared by the noise rush to the net. In the gill net, the fishes when trying to swim through, are gilled in between the meshes.

III. Cast net:

(a) Veechubalae: This is the most common net of the coast. These nets are made up of fine quality cotton or hemp. The length of the net varies, the most common form being 22' long. The approximate coat of the net of the above mentioned size is about Rs.170/- This net is used throughout the year. The size of the mesh is ¼", and the net is fringed with lead weights. It is thrown by hand forming semicircular enclosures.

IV. Drag net:

(a) Gorbalae: This net is operated in shallow waters or in creeks. The net consists of 12-15 pieces, measuring 10' to 15' long and 6' to 7½' deep and is made up of cotton or hemp. The approximate cost of one piece works out to Rs.15/-. The net is kept in position by means of heavy weights attached to the lower end and wooden floats to the upper.

PART III

OBSERVATIONS ON THE REPRODUCTION OF THE SHORT BODIED SARDINE, SARDINELLA ALBELLA (VALENCIENNES).

C O N T E N T S

OBSERVATIONS ON THE REPRODUCTION OF THE SHORT BODIED SARDINE, SARDINELLA ALBELLA (VALENCIENNES)

1. INTRODUCTION

The sardines are represented in Indian waters by nine species, out of which only a few like *Sardinella longiceps* *Sardinella fimbriata*, *Sardinella gibbosa* and *Sardinella albella* occur in large shoals along certain regions of both east and west coasts of India. *Sardinella albella* contributes to a good fishery only along the west coast, but forms a very small percentage of the annual fish production in Bombay, Mysore and Kerala states. The total catch of this species in India during the past nine year period (1950 to 1958) is estimated to be 559 metric tons (Nair 1959). There is no fishery as such for *Sardinella albella* in Karwar waters, but occasionally stray specimens are landed in the catches. The present account deals with fecundity, maturation and spawning of this species based on the material obtained from a shore seine 'yendi' haul on 6-9-1956. The size of the fish referred to is only the total length. Since the fishes obtained at Karwar in September 1956 were in the advanced stages of maturity, it was thought that the observation based on this material may probably lead to an understanding of the various aspects on the biology of the fish. The fishes belonging to this species have been studied in comparatively recent times, beginning with Delsman's account in 1926 on the eggs of this species from the Bay of Batavia. Other published works are of John (1939), Bapat and Bal (1950), Vijayaraghavan (1953), Sekharan (1955), Chacko (1956) and Chacko and Mathew (1956).

2. FECUNDITY

Ovaries preserved in 5% formaldehyde were taken out and dried in folds of filter paper. Then the entire ovary was weighed to the nearest milligram. A small portion of the ovary from the middle region was then taken out and weighed accurately. This piece was teased on a micro-slide to separate all the ova from each other. Out of these, only those ova which could be distinctly seen by the naked eye were taken into consideration. Thus, the total number of mature eggs contained in this portion was counted. From this number the total number of eggs in the entire ovary based on the weight of the sample and the weight of the entire ovary was computed.

The question of fecundity of this species has barely been touched by the earlier workers. The number of ripe ova which gives an indication of the reproductive capacity of the fish during a particular spawning season was estimated from individuals ranging from 146 mm. to 155 mm. in total length. The approximate number of mature eggs in the ovaries of the gravid females of the size range mentioned above varied from 10,114 to 13,513 (Table No.I). It can be seen from the Table that the left ovary which is flabbier than the right one produces more eggs. The total number of eggs from both the ovaries is proportional to the weight of the ovaries. Fecundity has also been found to be proportional to the size of the ovary, which is in turn related to the size of the fish.

Table No.I

Showing the length of fish, weight of the ovary and the number of eggs in right and left lobes of the ovary.

Serial Number	Length of fish (mm.)	Weight of the ovary (gms.)	Number of eggs Right lobe	Number of eggs left lobe	Total number of eggs
1	153	3.550	4034	6080	10,114
2	155	3.375	4236	7116	11,352
3	153	3.195	4158	6184	10,342
4	149	3.105	4089	6130	10,219
5	150	4.160	4829	7684	13,513
6	150	3.620	4172	6092	10,264
7	146	3.060	4069	6153	10,222

3. MATURATION AND SPAWNING

Chacko and Mathew (1956) noticed the dominance of the females in the commercial catches of the west coast during most months of the year. In the ripe females (Stage IV), the ovary fills more than 3/4 of the abdominal cavity. The ovaries were often unequal in size, the left lobe being more bulky than the right. Data showing the variations in the lobes, together with the length and weight of the fish and the stages of maturity of all the specimens examined are given in Table No.2. It can be seen from the Table that the dimensions of the left lobe were significantly higher than the right one. Maximum dimensions of the ovary were observed in a specimen measuring 150 mm. in length. In this specimen the left lobe measured 57/20 mm. in length/breadth and the right lobe 56/10 mm. Since the left lobe was significantly larger than the right one the total number of eggs contained in it was also higher.

Table No.2

Showing the variations in the length and breadth of the two lobes, along with the length, weight and the stages of maturity of the specimens examined.

Serial Number	Length of fish (mm.)	Stage of maturity	Weight of fish (gms.)	Left Lobe Maximum length/ breadth (mm.)	Right Lobe Maximum length/ breadth (mm.)
1	153	IV	37.340	50/15	51/10
2	155	IV	38.467	55/16	55/12
3	153	IV	37.770	57/17	57/12
4	149	IV	25.250	56/17	55/09
5	150	IV	36.400	57/20	56/10
6	150	IV	36.550	57/15	55/11
7	154	IV	36.675	48/12	49/08
8	149	III	34.240	35/12	36/06
9	154	III	46.675	48/12	49/08
10	154	III	36.640	40/09	41/06

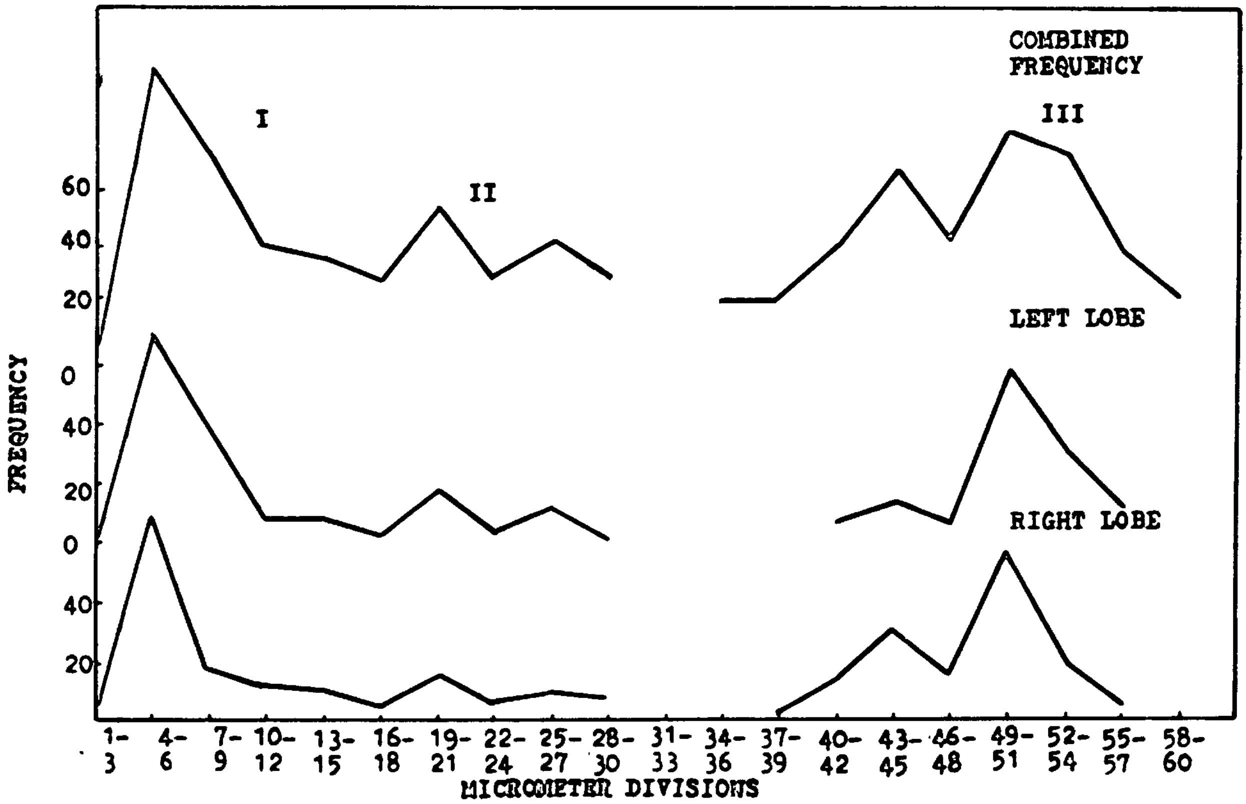
The maturation of the female sardine was studied by ova diameter measurements. For each ova sample, the technique of measurement and the assessment of maturity were the same as used for Opisthopterus tardoore. The following classification of the intra-ovarian eggs on the lines designed by Prabhu (1956) was adopted.

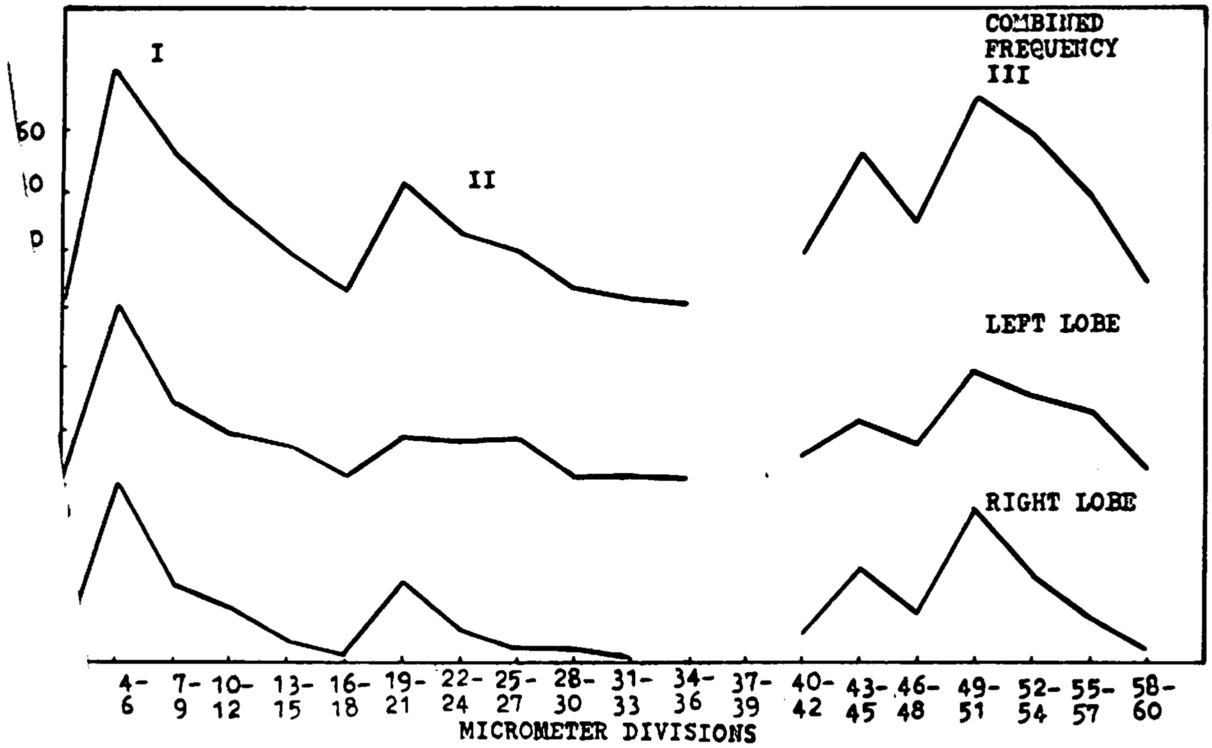
	STAGES	DESCRIPTION
A	IMMATURE	Minute transparent ova with distinct nucleus and a protoplasmic layer.
B	MATURING	Small opaque ova in which the formation of yolk has commenced but not fully yolked.
C	MATURING	Medium sized opaque ova
D	MATURE	Large sized opaque ova packed densely with yolk.
E	RIPE	Large, free, fully transparent eggs.

Text-Figures 1 to 6 show the frequency polygons of the diameters of all the ova measured from six different individuals ranging from 149 mm. to 155 mm. in size. The diameter of the intra-ovarian eggs varied from 0.051 mm. to 1.020 mm. From the modes of the curves in the Text Figures, different stages could be recognized in the maturation of the ova. It is seen that the ova ranging in size from 0.680 mm.

ext-Figure 2. Ova diameter frequency polygons of *Sardinella albella* (Valenciennes). Total length of the fish : 150 mm.

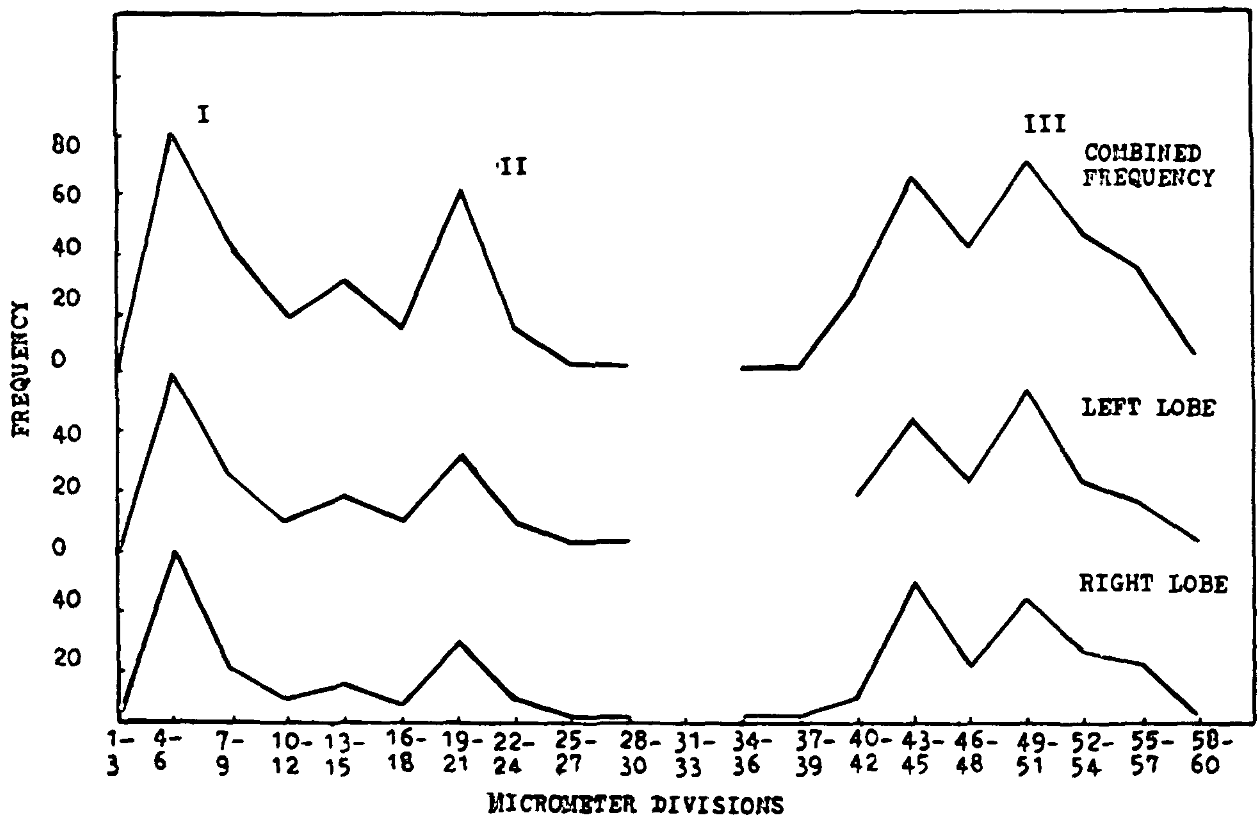
ext-Figure 1. Ova diameter frequency polygons of *Sardinella albella* (Valenciennes). Total length of the fish : 149 mm.


COMBINED FREQUENCY
LEFT LOBE
RIGHT LOBE
I
II
III
FREQUENCY
60
40
20
0
40
20
0
40
20
1- 3
4- 6
7- 9
10- 12
13- 15
16- 18
19- 21
22- 24
25- 27
28- 30
31- 33
34- 36
37- 39
40- 42
43- 45
46- 48
49- 51
52- 54
55- 57
58- 60
MICROMETER DIVISIONS


COMBINED FREQUENCY
III
I
II
LEFT LOBE
RIGHT LOBE
4- 6
7- 9
10- 12
13- 15
16- 18
19- 21
22- 24
25- 27
28- 30
31- 33
34- 36
37- 39
40- 42
43- 45
46- 48
49- 51
52- 54
55- 57
58- 60
MICROMETER DIVISIONS

Text-Figure 4. Ova diameter frequency polygons of *Sardinella albella* (Valenciennes). Total length of the fish : 153 mm.

Text-Figure 3. Ova diameter frequency polygons of *Sardinella albella* (Valenciennes). Total length of the fish : 155 mm.


FREQUENCY
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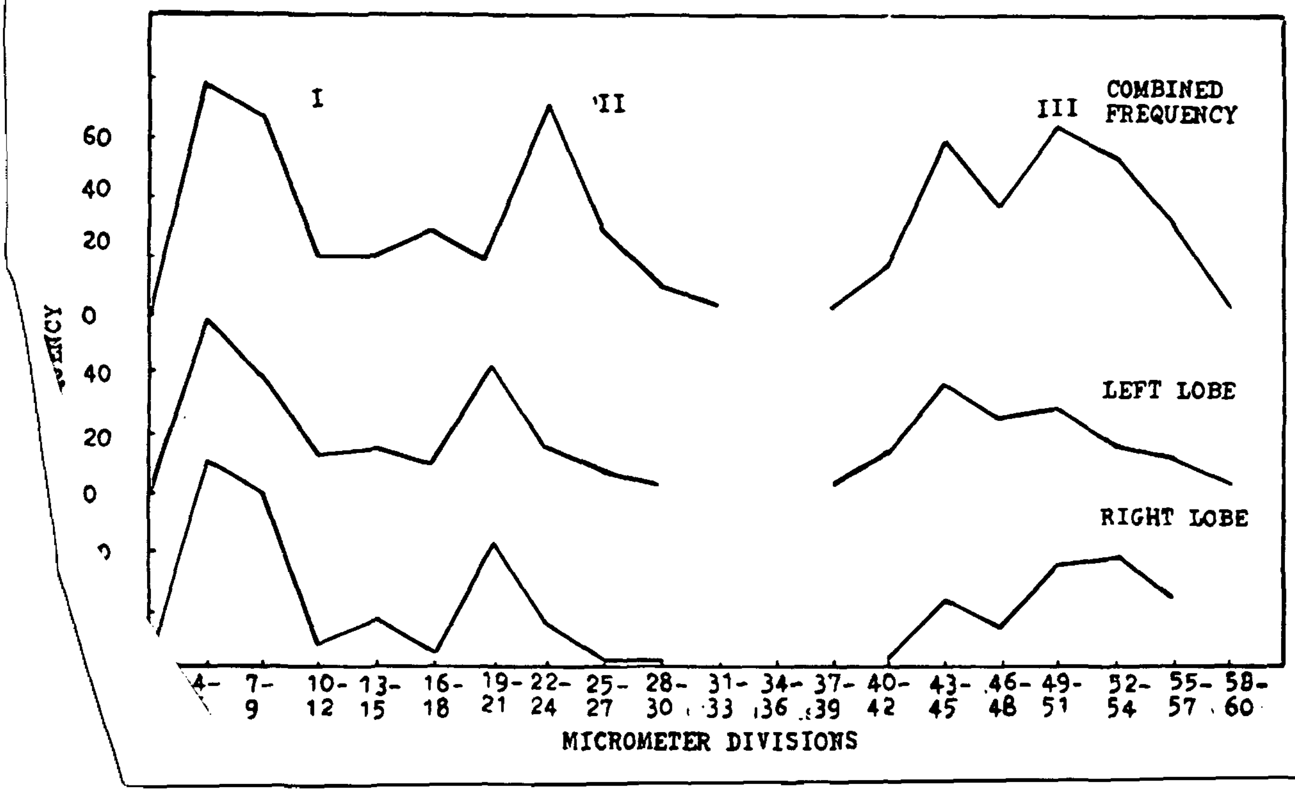
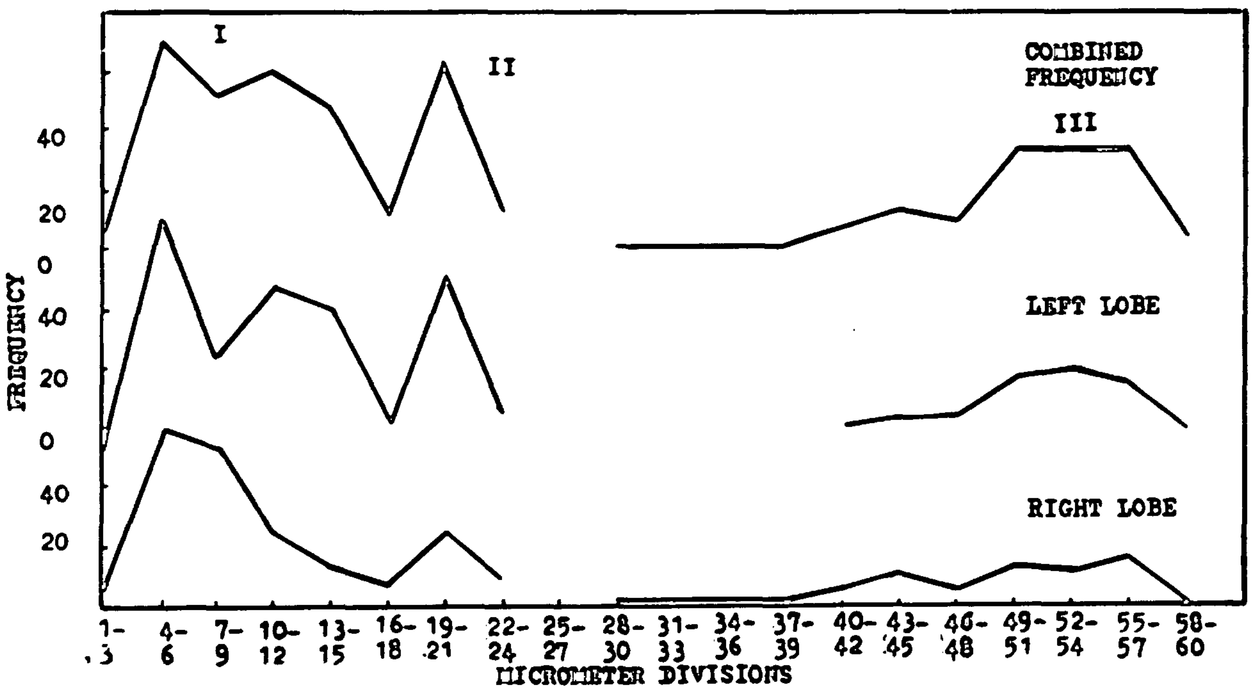
60
40
20
0
40
20
0
40
20
I
II
III
COMBINED FREQUENCY
LEFT LOBE
RIGHT LOBE
1-3 4-6 7-9 10-12 13-15 16-18 19-21 22-24 25-27 28-30 31-33 34-36 37-39 40-42 43-45 46-48 49-51 52-54 55-57 58-60
MICROMETER DIVISIONS


60
40
20
0
40
20
0
I
II
III
COMBINED FREQUENCY
LEFT LOBE
RIGHT LOBE
4- 7-9 10-12 13-15 16-18 19-21 22-24 25-27 28-30 31-33 34-36 37-39 40-42 43-45 46-48 49-51 52-54 55-57 58-60
MICROMETER DIVISIONS

Text-Figure 6. Ova diameter frequency polygons of *Sardinella albella* (Valenciennes). Total length of the fish : 149 mm.

Text-Figure 5. Ova diameter frequency polygons of *Sardinella albella* (Valenciennes). Total length of the fish : 153 mm.


I
II
III
COMBINED FREQUENCY
LEFT LOBE
RIGHT LOBE
FREQUENCY
40
20
0
MICROMETER DIVISIONS
1-3
4-6
7-9
10-12
13-15
16-18
19-21
22-24
25-27
28-30
31-33
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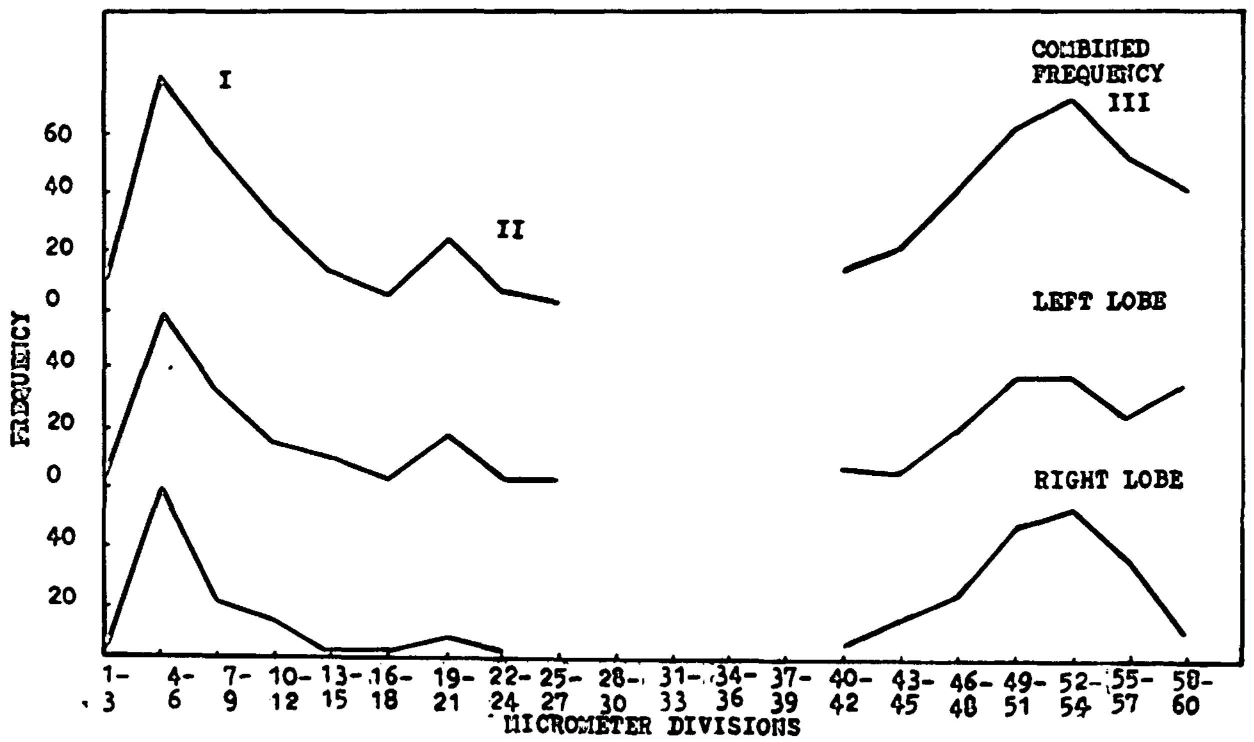
52-54
55-57
58-60


I
II
III
COMBINED FREQUENCY
LEFT LOBE
RIGHT LOBE
FREQUENCY
60
40
20
0
MICROMETER DIVISIONS
1-3
4-6
7-9
10-12
13-15
16-18
19-21
22-24
25-27
28-30
31-33
34-36
37-39
40-42
43-45
46-48
49-51
52-54
55-57
58-60

to 1.020 mm. are the stock of eggs likely to be shed during the forthcoming spawning season and from the fact that they are sharply differentiated from the rest of eggs in stages 'a' to 'c', it is quite probable that this species spawns only once a year. Since the stock of eggs in the ripe condition ~~have~~ has a wide range in diameter, it is likely that the actual process of shedding the ova may not be limited to a very short period, but may be extended over a longer period. From the Text Figures, it is also seen that the mode II also gets differentiated from the general eggs stock. The maximum size of the ova in this mode is seen at 0.510 mm. which is about half the size of those present in the ripening stock under mode III. Possibly the former forms brood of subsequent years. The absence of multiple modal curves and the presence of only two widely separated groups of eggs, further confirm that this species spawns only once a year.

4. DISCUSSION

The above findings are in agreement with the observations made on the spawning habits of this species by Sekharan (1955) The maximum size of the intra-ovarian eggs (1.020 mm.) recorded in the present study does not represent the size of the ova of the spawning fish. Probably the fully ripe ova are slightly larger than the above mentioned size. The ripe intra-ovarian eggs measuring 0.680 mm. to 1.020 mm. with a peak at 0.850 mm. are transparent and the yolk is provided with a single oil globule, the diameter of which ranges from 0.102 mm. to 0.119 mm. From the ova diameter frequencies of this species as shown by Sekharan (1955), it is noticed that the mode of the mature ova is at 0.50 mm. Delsman (1926) collected the eggs of this species, which measured 1.1 mm. to 1.2 mm. He stated that the presence of a double egg membrane and a small oil globule are the main distinguishing features of the eggs. Chacko and Mathew (1956) recorded the eggs from the west coast of India, the diameter of which varied from 1.02 to 1.2 mm.

The size range of the individuals landed in Karwar during September 1956 varied from 141 mm. to 164 mm., with an average at 150 mm. The maximum size of the fish recorded by Sekharan (1955) in his analysis is 125 mm. Chacko and Mathew (1956) have indicated that the largest specimen measuring 180 mm. were landed in February-April-June and November.

Sekharan (1955) suggested that the spawning season of this fish extends from February-March to June or July. Chacko and Mathew (1956) stated that the spawning takes place during pre-monsoon months extending from March to May along the west coast. John (1939) observed that this species spawns on the west coast from April to June. These workers have indicated that the spawning period extends upto June-July. The present work seems to be the first record of the occurrence of ripe individuals as late as September.

PART IV

OBSERVATIONS ON THE MACKEREL FISHERY, RASTRELLIGER CANAGURTA, (CUVIER) AT KARWAR FOR THE "SEASONS" 1954-1955 AND 1955-56.

CONTENTS

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OBSERVATIONS ON THE MACKEREL FISHERY, RASTRELLIGER CANAGURTA (CUVIER) AT KARWAR FOR THE "SEASONS" 1954-1955 AND 1955-1956.

1. Introduction

It has been pointed out that the mackerel and the sardines together support a fishing industry of very high magnitude, employing several thousands of people and unexpected large-scale fluctuations are a serious handicap to the full utilization of the fisheries. (Panikkar, 1956). An exceptionally poor yield of mackerel was noted during the last two seasons. During the 1954-55 and 1955-56 seasons the total catches dwindled to 966.466 and 516.458 metric tons respectively from the high peak of 2286.112 metric tons in 1951-52. Thus the mackerel fishery which has been considered the mainstay of Karwar fishery dwindled to a mere shadow of its former flourishing state in the last two years.

The programme of mackerel work hitherto carried out at Karwar, was altered during the 1955-56 season, with more emphasis laid on the intensive collection of data on the length frequency distribution and on mackerel landings at important fishing centres like Majali, Binge, Chendia

Ankola, Kumta, Honavar and Bhatkal on the North Kanara Coast. Weekly observations were made at these selected centres, the data being collected throughout the season for comparative study. The magnitude of the mackerel fishery at a particular place and its fluctuations from year to year could ofcourse be gauged very well from the records if they were maintained continuously over a number of years.

2. General Trend of Fishery at Karwar

The mackerel season at Karwar and all along the North Kanara Coast is usually from October to February. and at times extends to March. During the season the fishing operations which are conducted by Rampan nets are restricted to a narrow strip of inshore coastal water almost one and a half miles wide. The mode of operation of the Rampan net and the types of boats and nets used in the fishery have been described by Pradhan (1956).

The mackerel season for the year 1954-55 commenced late owing to the prolonged rainy season. The first Rampan operation at Karwar was on 4-11-1954 when about 2,00,000 mackerel were recorded as netted. The intensity of fishing was at its highest during the second and third weeks of November 1954, when on the same day, 3 to 4 Rampan nets were plied. Frequent breaks were noted in the fishing activity during the months of December and January 1955. From January onwards, the mackerel fishery was completely eclipsed by the oil sardine fishery. The season ended by about the third week of February.

The mackerel season of the year 1955-56 commenced at all places in Kanara Coast in October 1955 - earlier than the previous season. The season started very well and the catches were very promising. November and December, which are considered to be the best months for the mackerel fishery were comparatively poor this season. The first Rampan operation at Karwar was on 24-9-1955, when about 17,500 mackerel together with miscellaneous fishes of small sizes were caught. The catches of mackerel improved towards the end of November 1955, but later on, the fishery dwindled considerably. The last Rampan operation at Karwar was on 28-3-1956 when about 57,000 mackerel were caught.

3. Catch per unit effort of fishing.

The primary objective of research on 'capture fisheries' is to determine the condition of the resources in relation to the abundance of the different species of fish that are taken in the fishing operations. The total catch is not a good measure of abundance that takes into consideration, the amount of fishing is the "catch-per-unit-of-effort". The formula N/P is used to calculate the unit of effort (catch per piece per haul) where N and P are the number of mackerel caught and the number of pieces in the Rampan net respectively.

The total number of Rampans operated at Karwar for the 1954-55 and 1955-56 seasons were 97 and 88 respectively. The total quantity of mackerel caught, number of hauls and catch-per-unit-of-effort for each month during the two seasons are shown in Table I. It may be stated that the total number of pieces of the Rampan net operated and the number of hauls for the 1955-56 season were comparatively fewer. Viewing the table as a whole, we see that the maximum number of mackerel per piece were obtained only in the beginning in both the seasons, i.e., October for the 1955-56 season and November for the 1954-55. Later months show a decrease in the catch-per-unit. The minimum recorded for the 1954-55 and 1955-56 seasons were for the months of January 1955 and February 1956 respectively. We also notice a secondary peak period in the fishery towards the end of the two seasons. Thus the mackerel season can be classified into three phases on the basis of catch-per-unit-effort of fishing : (i) peak period of fishing, October-November, (ii) slack fishing activity, December-January and (iii) secondary peak period, February-March.

Table I

Catch per unit effort of fishing during the seasons 1954-55 and 1955-56-

Months	No. of mackerel caught (N)	No. of hauls	Catch per unit effort of fishing (N/P)
	1954-55 Season		
November	86,92,000	35	452
December	18,01,000	19	126
January	68,220	28	5
February	92,200	15	12.6
	1955-56 Season		
October	24,14,000	7	389.3
November	14,60,600	20	132.1
December	8,56,900	21	69.8
January	7,60,200	10	69.9
February	38,600	10	6.3
March	1,62,800	10	33.5

P - Number of pieces in the Rampan net.

4. Length frequency distribution of Mackerel

Length frequency studies were based on random samples collected regularly when there was fishing for mackerel in Karwar Bay. The length frequency data for the seasons are shown in Tables II and III. Mackerel measured for dominant size class during the 1954-55 season totalled 2039. For November 1954, the beginning of the season, a mode at 210-219 mm. size group was prominent. For December 1954, two modes one at 190-199 mm. and the other at 220-229 mm. size groups were seen, and for January, February and March at 200-209 mm., 220-229 mm., and 220-229 mm. respectively. During the 1955-56 season, 2163 mackerel were measured for plotting length frequency distribution. For October 1955, one mode at 160-169 mm. and the other mode at 210-219 mm. were seen. For November 1955 and February 1956, the modes appeared at 210-219 mm. and 220-229 mm. respectively. For March 1956, a mode at 210-219 mm. size group was seen.

Tables IV shows the seasonal length frequency distribution (October to March) of mackerel at Karwar for the seasons 1954-55 and 1955-56. The range of size during the 1954-55 season was from 171 mm. to 247 mm. as against 140 mm. to 247 mm. during the 1955-56 season. Viewing the Tables as a whole we see two modes for the 1955-56 season, one at 160-189 mm. and the other at 210-219 mm.

TABLE II

Length-frequency distribution of mackerel at Karwar
for 1954-55 season

Size-groups	November	December	January	February	March
170-179 mm.	...	4(0.8)	...	...	...
180-189 mm.	4(0.4)	62(13.4)	5(2.2)	...	...
190-199 mm.	83(7.2)	120(26.0)	46(20.4)	1(0.49)	...
200-209 mm.	217(19.0)	91(19.7)	82(36.4)	1(0.49)	...
210-219 mm.	327(18.5)	67(14.5)	46(20.4)	34(16.8)	5(18.9)
220-229 mm.	323(18.3)	104(22.8)	36(11.1)	81(40.1)	14(51.8)
230-239 mm.	184(16.0)	23(4.9)	7(3.1)	71(35.1)	6(22.2)
240-249 mm.	3(0.3)	...	2(1.3)	14(6.9)	2(7.5)

(The figures in brackets are percentages)

Table III

Length-frequency distribution of mackerel at Karwar

for 1955-56 season

Size-groups	October	November	February	March
140-149 mm.	11(2.4)	...	...	...
150-159 mm.	34(7.4)	...	...	...
160-169 mm.	107(24.2)	...	...	...
170-179 mm.	51(11.3)	21(2.4)	...	...
180-189 mm.	73(16.5)	33(3.8)	...	...
190-199 mm.	2(0.4)	56(6.4)	...	...
200-209 mm.	59(13.3)	193(22.3)	9(3.7)	27(12.7)
210-219 mm.	94(21.1)	366(42.3)	29(36.2)	77(36.4)
220-229 mm.	11(2.4)	126(14.5)	42(52.6)	58(27.3)
230-239 mm.	...	47(5.4)	6(7.4)	40(18.8)
240-249 mm.	...	24(2.8)	...	10(4.7)

(The figures in brackets are percentages)

Table IV

Seasonal length-frequency distribution of mackerel for 1954-55 and 1955-56 seasons.

Size-groups	1954-55 season	1955-56 season
140-149 mm.	...	11(0.6)
150-159 mm.	...	24(2.1)
160-169 mm.	...	107(6.6)
170-179 mm.	4(0.1)	72(4.5)
180-189 mm.	71(3.1)	106(6.6)
190-199 mm.	250(12.2)	58(3.6)
200-209 mm.	391(14.2)	282(17.6)
210-219 mm.	474(23.2)	566(35.3)
220-229 mm.	544(26.6)	237(14.6)
230-239 mm.	285(13.9)	93(5.8)
240-249 mm.	20(0.9)	34(2.1)

(The figures in brackets are percentages)

Only one mode at 220-229 mm. was noticed in the 1954-55 season. Pradhan (1956) states that when the dominant size class was small, the seasonal catch of mackerel was also comparatively small, as seen in the 1949-50 and 1952-53 seasons. He further states that it appears that the direct relation of catch to dominant size group holds good only when the fishery is contributed by one size group persisting throughout the season. This hypothesis may be correct for the 1955-56 season, as two dominant size groups persisted in the fishery during the period, but it may be pointed out that the distinction made by Pradhan for small and large dominant size groups is rather confusing.

No true understanding of the mackerel fishery or the mackerel population can be reached until the size fluctuations occurring within each fishing season are clearly set forth. The significance of the occurrence of various size groups during different periods on the west and east coasts of India can be better understood by comparative studies and length frequency distribution of mackerel, landed on both the coasts. For comparative studies, samples were obtained from Majali, Ankola and Kumta during the 1955-56 season, but no marked difference in the size ranges were noticed between the samples from the different centres. The length frequency chart of mackerel at these centres for the 1955-56 season are shown in Table No.V.

Table V

Length-frequency chart of mackerel at Kumta, Majali and Ankola for the 1955-56 season.

Size groups	Kumta		Majali			Ankola
	December	January	December	January	February	January
160-169 mm.	6(2.5)	...	...	...	...	...
170-179 mm.	41(16.8)	1(0.3)	...	...	...	...
180-189 mm.	117(47.8)	1(0.3)	3(2.3)	...	...	...
190-199 mm.	71(29.3)	46(18.3)	17(17.8)	10(10.6)	...	19(13.2)
200-209 mm.	9(3.6)	118(47.0)	22(21.7)	38(40.4)	4(9.9)	64(44.3)
210-219 mm.	...	45(17.5)	15(14.8)	29(30.9)	19(42.3)	55(38.3)
220-229 mm.	...	35(13.9)	32(31.6)	17(18.0)	21(47.7)	6(4.1)
230-239 mm.	...	5(1.9)	7(6.9)	...	...	...
240-249 mm.	...	...	4(3.9)	...	...	...

(The figures in brackets are percentages)

Kumta: For December and January, one mode each at 180-189 mm. and 200-209 mm. size groups respectively were noticed.

Majali: For December two modes appeared, one at 200-209 mm and the other at 220-229 mm. For January the first mode remained stationary and for February, it had moved to 210-219 mm.

Ankola: For January a mode at 200-209 mm. was noticed.

It is gathered that the mackerel in the maturity stages I and II constitute the fishery along the coast and that the fishery draws its support mainly from a single age group.

5. Mackerel Fishery in Relation to Sardine Fishery

Nair (1952) states that the fluctuations in the oil sardine (*Sardinella longiceps*) fishery seen within the season do not in any way influence the course of mackerel fishery. Studies have been initiated already at Karwar to see how far the sardine fishery is complementary to the mackerel fishery of this area. The oil sardine fishery was good for the 1954-55 season, (November to March) the total landings being 160.332 metric tons. Even after March, good landings were noted at Karwar for the succeeding three months. During the 1955-56 season the sardine shoals did not enter the inshore waters at Karwar. The estimated landings of mackerel and oil sardines are shown in Table VI.

Table VI

Estimated landings of mackerel and oil sardines in Kilograms for the 1954-55 and 1955-56 seasons at Karwar.

Months	1954-55 season		1955-56 season	
	Mackerel	Oil sardine	Mackerel	Oil sardine
October	...	...	2,15,477.58	Nil
November	7,88,524.38	648.64	1,32,494.24	Nil
December	1,63,383.85	2,694.33	77,736.66	Nil
January	6,188.80	1,04,784.33	68,964.12	Nil
February	8,364.24	34,745.21	3,501.74	Nil
March	...	17,506.43	14,769.00	Nil

6. Observations on Mackerel Fishery at Eight Centres

Information on the mackerel fishery during the 1955-56 season at eight centres of observation has been summarized and shown below in Table VII. The mackerel fishery for the 1955-56 season was a complete failure throughout the Kanara coast, except at Honavar, where the season could be termed good, after comparison with the last few years' catch statistics.

One interesting feature during November-December of the 1954-55 season was that the jelly fishes were caught in large numbers along with mackerel. Lucas and Henderson (1936) studied the correlation between the jelly fish and herring. The association between certain species of Carangids and jelly fish is well known, and such an association has already been reported by Panikkar and Prasad (1952). The abundant occurrence of the jelly fish at the beginning of the season is considered by the local fishermen to be an indication of a poor fishery to come. The data collected at Karwar do not warrant the putting forward of any explanation at this stage, and a great deal of evidence has yet to be collected before any positive conclusion can be advanced.

TABLE NO.VII

OBSERVATION CENTRE	KARWAR	BINGE	CHENDIA	ANKOLA	KUMTA	MAJALI	HONAVAR	BHATKAL
Duration of season	OCTOBER 1955 TO MARCH 1956.							
Whether season was good/bad	Bad	Bad	Bad	Bad	Bad	Bad	Much better than last two years.	Bad
Type of nets employed	Rampan	Rampan	Rampan	Rampan	Rampan	Rampan	Gill-nets and Cast nets.	Gill-nets
Number of Rampan nets in operation.	15	4	7	3	1	8	-	-
Number of hauls	88	118	51	6	13	14	-	-
Catch during different months of the season (all figures are in numbers)								
October 1955	24,14,000	20,63,199	The estimated total landings for the season are 29,71,275.	4,30,000	60,000	1,00,000	The estimated total landings of mackerel upto January are 2,50,000.	The estimated total landings are 2,50,000
November 1955	14,97,000	55,555		...	4,00,000	3,61,000		
December 1955	8,56,900	3,48,340		...	24,200	87,500		
January 1956	7,60,200	3,52,125		95,000	50,000	1,00,000		
February 1956	38,600	1,29,860		...	...	90,000		
March 1956	1,62,800	1,38,861		...	...	4,37,000		
Size composition of the catch during the season.	140-240 mm.	150-240 mm.	180-245 mm.	140-230 mm.	140-220 mm.	160-240 mm.	150-230 mm.	180-230 mm.
Disposal of catch	Fresh 60% Cured 40%	Fresh 50% Cured 50%	Fresh 50% Bured 50%	80% to 90% cured and the rest sold as fresh fish in the market.	Fresh 50% Cured 50%	Fresh 50% Cured 50%	Fresh 50% Cured 50%	Fresh 50% Bured 50%
Places of distribution and mode of transport.	Fresh fish taken direct to Bombay by fish-carrier launches; cured fish sent to Ratnagiri, Malwan, Belgaum, Hubli, Dharwar and Colombo.							

SUMMARY

During the course of the present investigation some aspects of the biology of the following Indian marine food fishes were studied:

1. *Sillago sihama* (*Forskal*)
2. *Opisthopterus tardoore* (*Cuvier*)
3. *Sardinella albella* (*Valenciennes*)
4. *Rastrelliger canagurta* (*Cuvier*)

1. *SILLAGO SIHAMA* (*FORSKAL*)

This investigation was based on samples obtained from Mandapam and Rameshwaram Island in the Gulf of Mannar and Palk Bay.

The study of the growth rate of different parts of the fish has shown that the standard length and the depth of the body through pectoral fin base have the maximum and minimum rates of growth. The relationship between total length and standard length was found to be $Y = 0.98x - 0.70$.

Analysis of the stomach contents showed that polychaetes formed by far the greater part of the food consumed. A list of organisms found in the gut contents and the monthly variation in the proportion of the three chief food components, polychaetes, crustaceans and fish, is given. An increased feeding activity after spawning and a low feeding activity before spawning were noticed.

By the study of frequency distribution of intra-ovarian eggs it was concluded that the fish has a single spawning period in the course of the year. The spawning season extends from August to February, with the peak in October. From the fluctuations in the ponderal index it has been inferred that the fish matures for the first time when it attains an average length of 130 mm. From the study of the rate of growth of gonads, the length and breadth of the ovary have been found to increase at a greater rate than the testis. It was noticed that the males form a slightly higher percentage of the catches than the females, the percentage of males and females being 55.6 : 44.4

The length-weight relationship formula was found to be $W = 0.01504\ L^{2.8862}$.

The relationship between otolith length and length of the fish was determined. The rate of growth computed from the study of otoliths indicated an increase of 4.24 cm., 3.38 cm. and 1.61 cm. for the one, second and third years respectively. It was concluded that the reduced rate of feeding at the time of maturation of the gonads may probably be the cause of the periodic formation of the rings in the otoliths. The length frequency distribution for a period of one year is presented and discussed. The age estimates obtained by the study of otoliths more or less agreed with the length frequency polygons upto one and second year classes.

The extent of distribution of Sillago sihama in India and a brief account of the fishing methods on the east and the west coasts are given.

2. OPISTHOPTERUS TARDOORE (CUVIER)

A comprehensive study of the biology of the long finned herring was undertaken. The account presented embodied the results of the investigation carried out at Karwar from 1956 to 1960.

In analysing the morphometric data the analysis of covariance was adopted for all the thirteen characters.

No significant difference was noticed in respect of the regressions of the length upto anus, length of maxillary and height of head on standard length from all the four localities. Regression of maximum body depth along the anal fin was found to vary significantly. Therefore, it was concluded that these four characters are not likely to be useful in the delimitation of the stocks. The result of the analysis of covariance of nine regressions on standard length showed significant differences and thus, it provided sufficient reasons to believe that the entire Kanara coast fishery of Opisthopterus tardoore is not supported by a common stock.

There were no significant differences in the morphometric characters of the samples obtained from Bhatkal and

Murdeshwar. The samples of both these places either come from a single stock or from closely related stocks. Mangalore samples were found to be more allied to Bhatkal-Murdeshwar and those of Karwar were quite independent of the rest.

The relation between all the thirteen body measurements against standard length was found to be linear.

The fish matures for the first time when it grows to a length of 150-169 mm. Sex distribution of the monthly totals revealed that the females were more numerous than the males. The growth of the maturing eggs has been illustrated by frequency polygons. Ova diameter studies indicate that <u>Opisthopterus tardoore</u> spawns only once a year and the entire stock of ova measuring 0.510 mm. and above are shed during spawning. The spawning season of this species lasts from late February or early March to July and August.

The weight-length relationship formula was found to be $W = 0.004508\ L^{2.2897}$. The values obtained for ponderal indices gave evidence that the size at first maturity is 150 mm. This falls in close agreement with the size determined by studying the cycle of gonad condition.

The size group with the highest frequency was 80-89 mm. for 1956, whereas for subsequent fishery seasons it was 90-99 mm. The fishery was mostly supported by I year old fishes during 1957 and 1959 and I and I+ year groups during 1958 and 1960. But, during 1956 the fishery included 0-year group also. The normal modal size of one year old fish appears to be 90-99 mm. At the end of the second year it approximately reaches 140-149 mm.

Opisthopterus _tardoore_ is a carnivorous fish. Its main food item is composed of _Mysids_, _Pseudodiatomus_ and copepod eggs. Items of minor importance are _Acetes_, _Acrocalanus_, Lucifer, prawns, bivalve eggs and larvae, _Cypris_ larvae, _Coscinodiscus_ and amphipods. Fish larvae and fish scales are also found in the guts. The total volume of the food in the stomach ranges from 0.06 c.c. to 0.08 c.c.

The crafts and the fishing methods employed for the '_pachki_' fishery along the Kanara coast have been briefly mentioned.

3. SARDINELLA ALBELLA (VALENCIENNES)

The account given deals with fecundity, maturation and spawning based on the material obtained at Karwar. It was observed that the approximate number of mature eggs in the ovaries of the gravid females measuring 146 mm. to 155 mm. varies from 10,000 to 13,500. The left lobe of the ovary which is flabbier than the right one produces more eggs, the number being directly proportional to the size of the ovary. The structure and variation in the sizes of gonads are also given. The maximum size of the intra-ovarian eggs recorded was 1.020 mm. The ripe eggs vary in diameter from

0.680 mm. to 1.020 mm. In mature ovaries there is a distinct batch of ripe eggs clearly seperated from the immature stock and that the ripe stock of eggs have a wide range in diameter. These features indicate that the species spawns once a year, but the duration of spawning may extend over a long period.

4. RASTRELLIGER CANAGURTA (CUVIER)

General trend of the mackerel fishery (Rastrelliger canagurta) at Karwar for the "seasons" 1954-55 and 1955-56 are given. During these two seasons the total catches of mackerel dwindled to 966.466 and 516.458 metric tons respectively, from the high yield of 2286.112 metric tons in 1951-52 season. The mackerel season lasts generally from October to February and at times extends upto March. A secondary peak period in the fishery was noticed towards the end of both the seasons in the months of February and March, with the primary peak occurring in October-November. There appears to be no marked difference in the size groups of mackerel caught at Karwar, Majali, Ankola and Kumta during the 1955-56 season. Length frequency studies revealed that two dominant size groups namely 160-189 mm. and 220-229 mm. entered the fishery of 1955-56 as against one size group (220-229 mm.) in 1954-55. The mackerel in maturity stages I and II constitute the fishery along the coast, which draws its support mainly from a single age group. Information on the mackerel fishery at eight observation centres along the North Kanara coast has been summarised.

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